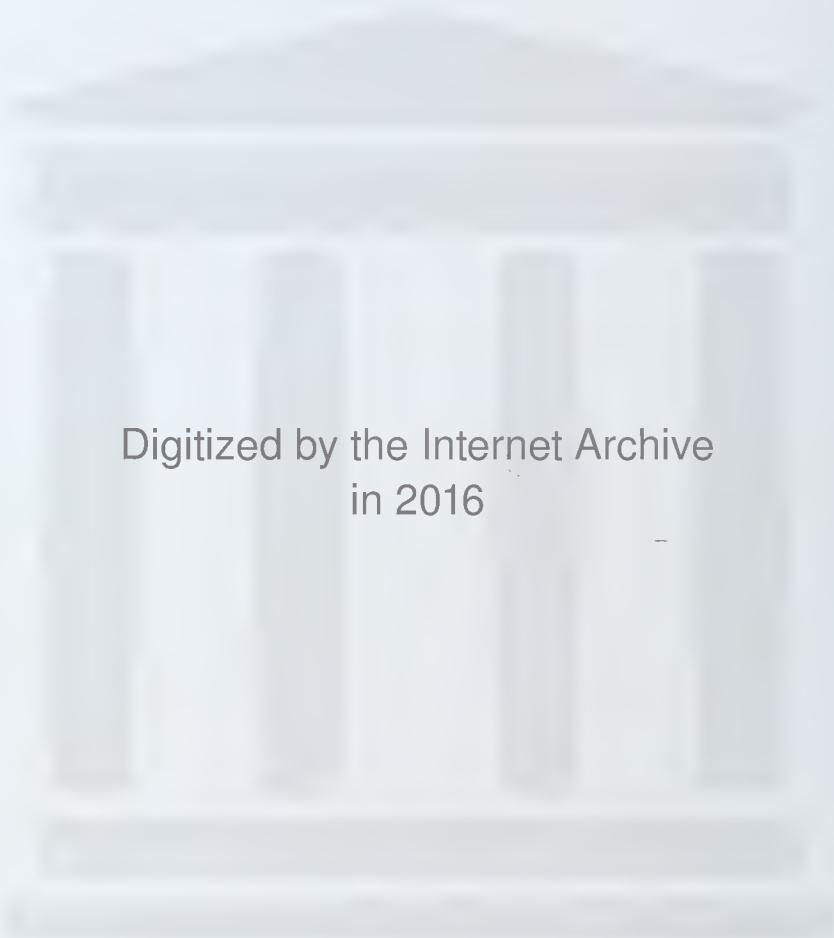
Metal Forming



Metal Forming

AS AN AREA OF

INDUSTRIAL ARTS INSTRUCTION IN PENNSYLVANIA PUBLIC SCHOOLS

SUBJECT AREAS

Automotive	Home Mechanics	Plastics
Ceramics	Metal Forming	Sheet Metal
Electricity	Metal Machining	Textiles
Graphic Arts	Planning	Woodworking

Bulletin 331F • 1953

COMMONWEALTH OF PENNSYLVANIA

DEPARTMENT OF PUBLIC INSTRUCTION • Harrisburg

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Foreword

METAL FORMING is one of a series of bulletins on specific areas of instruction in the broad field of Industrial Arts education. It supplements *Industrial Arts in Pennsylvania,* Bulletin 331, published in September, 1951, by the Department of Public Instruction.

This bulletin was prepared by Michael W. Knerr, Senior Area Coordinator of Trade and Industrial Education, under the direction of Robert T. Stoner, Chief of Trade and Industrial Education. Layout planning was done by R. Randolph Karch, Adviser, Trade and Industrial Education. Photographs and shop layout are the work of Lyle Weissenfluh, Adviser, Trade and Industrial Education.

Valuable assistance in the preparation of this bulletin was given by the following Industrial Arts teachers: G. Lawrence Brown, Milton; William J. Brown, Forty Fort; George Gold, Elysburg; Leon Maxfield, Susquehanna; and Bruce Rathburn, Tunkhannock. Assistance in the preparation of various teaching units was given by: Lewis Russell of the Berwick Public Schools in welding; Amos D. McGary of the York City Schools in heat treatment; and Richard G. Flick of the Somerset Joint School District in cold forming.

Rachel S. Turner, Editor for the Department of Public Instruction, has edited this bulletin.

Francis B. Haas

Superintendent of Public Instruction

September 1953

Department of Public Instruction

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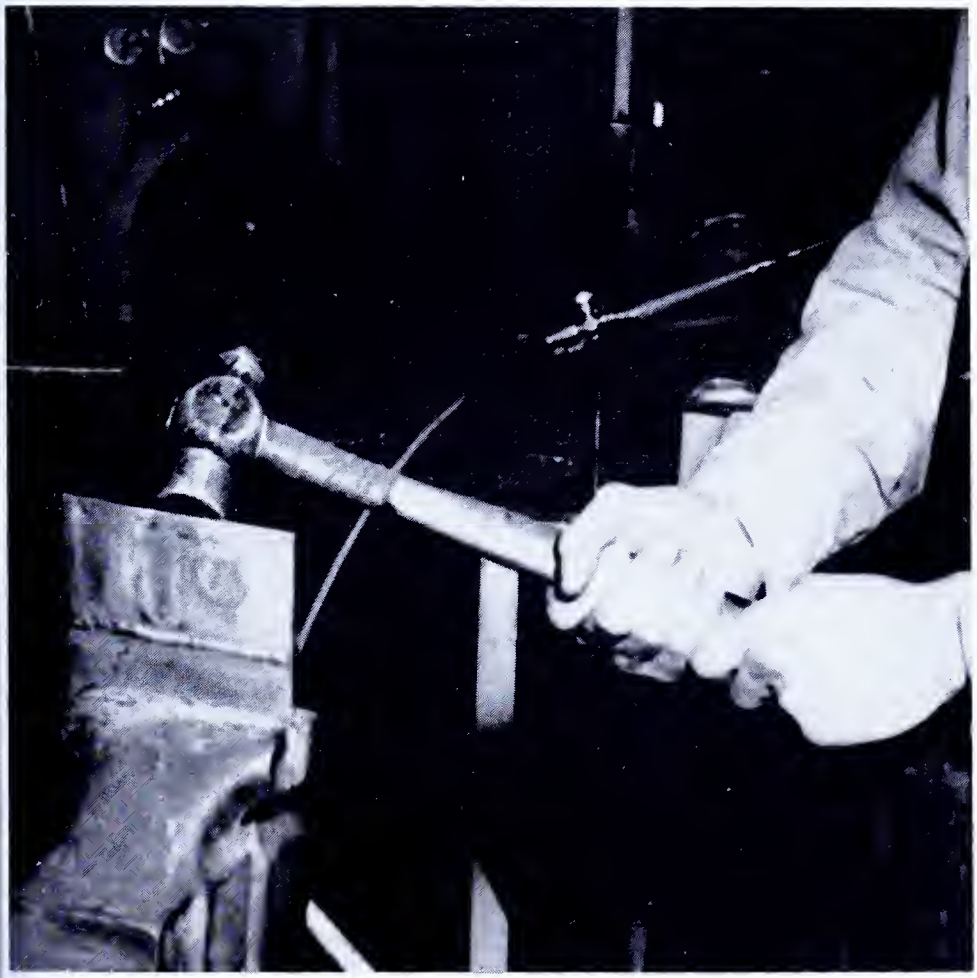
Contents

Introduction

INDUSTRIAL ARTS INSTRUCTION might well begin with Metal Forming tools, materials, and processes. Metal and metal products manufacturing leads all industry in value of goods produced in 34 counties of the Commonwealth.[1] The title, "Arsenal of America," has been earned by Pennsylvania because of her leading position in manufacturing and processing metal and metal products for defense purposes.

Metal Forming deserves primary consideration because it is the area in which many general metal shop projects have their beginning and where such processes as founding, forging, and extruding are introduced.

[1] *Twelfth Industrial Directory,* Department of Internal Affairs, Commonwealth of Pennsylvania, 1950.



Industrial Arts pupils will utilize metal with pleasure in constructing worthwhile objects involving other materials and facilities in the comprehensive general shop.

Because of the differences in educational concepts and backgrounds of administrator and teacher, because of variation in the time pupils spend in the activity, in amount of funds available for equipment and supplies, as well as other factors, no attempt is made in this bulletin to set up a common course of study applicable to all situations, or to tell the teacher what to teach, or how to teach, or what equipment he should have in his shop. From the "Things to Do" and "Things to Know" sections of this bulletin on pages 5 through 24, the teacher may find suggestions for the course content which best answers his particular aims and objectives. The time and equipment available to pupils in the Metal Forming area must also be considered.

Suggestions to guide the administrator are made on the organization of instruction, instructional material, tools, and devices; shop management organization; sample project sheets; and the use of records and forms. Included for further guidance are: a selected annotated bibliography of readily available instructional materials and visual aids, a suggested inventory of equipment and supplies, their approximate cost, a shop layout, and other information related to establishing or enriching the Metal Forming Area of a comprehensive general shop or a general shop.

Matters pertaining to Industrial Arts in general are not discussed in this bulletin. For such material the reader is referred to Bulletin 331, *Industial Arts in Pennsylvania,* published by the Department of Public Instruction in September, 1951.

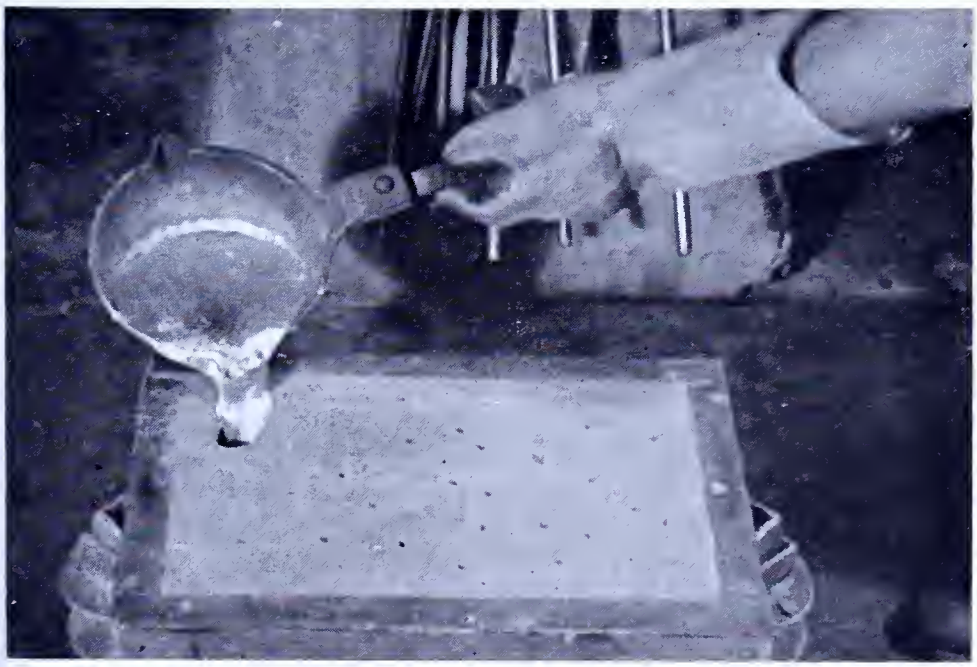
1 Metal Forming

AS A SCHOOL SUBJECT

Metal Forming Is a Collective Name for those industrial activities whereby metals are changed in form and structure by heating, pouring, pounding, and bending. These processes are utilized in producing the endless variety of shapes and forms in which society utilizes metal. The secondary school pupil can explore this industrial activity through organized experiences in foundry, forging, welding, heat treatment, cold forming and patternmaking. With pupil-teacher purposing and planning it is possible for every pupil to feel he is progressing and succeeding in the learning experiences he has set out to accomplish.

Aims and Objectives

The aims and objectives of Industrial Arts Education are fully covered on pages 15 through 34 in Bulletin 331, *Industrial Arts in Pennsylvania,* published by the Department of Public Instruction in 1951. In addition to these general aims and objectives, the specific



aims and objectives of Metal Forming in the Industrial Arts program include:

1. Understanding the importance of Metal Forming in manufacturing

2. Knowing the trend of employment and future opportunities in the metal forming industries

3. Knowing the safe use and care of hand tools, machine tools, and materials for Metal Forming

4. Acquiring elementary skills and knowledge of manufacturing processes by selecting projects which require the use of metal forming facilities

5. Learning of mass production methods by visiting metal forming industries

6. Developing into a more intelligent purchaser and consumer of metal-formed articles

7. Knowing the interdependence of planning in the various learning units of Metal Forming

Tools and Materials

The Metal Forming activity introduces the pupil to a great number of new tools and materials. Learning the proper names and uses of tools is basic for any occupational activity. Firsthand contact is made with such materials as beeswax, coke, fire clay, oxygen, molding sand, quenching oils, and mica necessary for processes in Metal Forming. Using a wide variety of materials and tools in constructing numerous useful articles is the primary method of attaining activity objectives.

Methods

Even though the Metal Forming area of a comprehensive general shop may be limited in equipment and tools, much can be taught about present-day methods of industry. In the foundry unit sand molds may be made and castings poured from aluminum alloys and lead. In the forging unit metals may be shaped, cut, punched, and tools reshaped. In the welding unit metals may be repaired, fabricated, cut, and welded joints tested. In the heat treatment unit metals may be hardened, tempered, surface-hardened, annealed, normalized, carburized, and hardness tested. In the patternmaking unit different kinds of patterns may be made from wood, aluminum, plaster of Paris, and plastic.

Processes

The processes of making a sand mold, as the hand molder does in the foundry, can be learned in the school shop. The processes of forging are similar to those in industry except that in industry machine power is substituted for the pupil's arm, and dies take the place of his hammer and anvil. Electric arc and oxyacetylene welding, and the annealing of aluminum, brass, and copper that have been cold-worked can be learned in the school shop.

Occupations

Vocational counseling of pupils for employment within the Metal Forming industries is an important function of Industrial Arts education. It must include a comprehensive system of authentic occupational information, secured or prepared by the teacher covering the duties, entrance requirements, wages and supplementary wage benefits, work performed, advancement opportunities, job outlook, job stability, and other characteristics of the major occupations within the Metal Forming industries. *Occupational Guides* and the *Occupational Outlook Summary*,[1] published by the United States Department of Labor are excellent sources of occupational information. The following occupational information should be provided: in the Foundry unit about the hand molder, coremaker, furnace tender, shake-out man, chipper, grinder, and metallurgist; in the Forging unit about the blacksmith, hammersmith, drop hammer operator, forging press operator, and upsetterman; in the Welding unit about the metallurgist, arc welder, acetylene welder, combination welder, flame cutter, burner, and brazer; in the Heat Treatment unit about the metallurgist, heat treater, furnace tender, and hardness tester; in the Patternmaking unit about the patternmaker, model maker, template maker, form builder, and loftsman.

Metal Forming as an Integral Part of a Comprehensive General Industrial Arts Shop

This bulletin is concerned largely with Metal Forming as an integral part of at least four activities in a comprehensive general Industrial Arts shop. The Metal Forming area is equipped to provide working and learning space for twelve pupils per class period.

The Metal Forming area may be combined with any of the other Industrial Arts areas to provide a comprehensive general shop or a general metal shop or any of the units may be selected to provide a unit shop (see pages 50 and 51, *Industrial Arts in Pennsylvania,* Bulletin 331).

[1] Order from U. S. Government Printing Office, Washington, D. C.

Subareas or units suggested for the Metal Forming area in the Comprehensive General Shop are foundry, forging, welding, heat treatment, patternmaking, and cold forming.

Metal Forming in a General Metal Shop

Metal Forming provides opportunities for a wide range of activities in metal materials, tools, and processes. Combined with other metal industrial arts subject areas, such as metal machining and sheet metal, it would function as a General Metal Shop providing for a wider range of metal activities.

2 Learning Units

THINGS TO Do

THE PURPOSE OF THIS BULLETIN is to suggest what is needed in developing a Metal Forming Area in a four-area comprehensive general shop. The Metal Forming Area is divided into the following six subareas or units: foundry, forging, welding, heat treatment, patternmaking, and cold forming. If only several of the suggested units are included, others may be added later until all six units have been developed.

Teachers of Metal Forming are encouraged to seek adequate instructional material covering not only the "Doing Units" but the "Knowing Units" as well. Adequate texts and study guides are listed in the annotated bibliography on pages 37 through 44.

The following list of "Things To Do" suggested for use in planning a Metal Forming Area of instruction, are broken down into the six units mentioned above. The list of "Things To Do" may seem lengthy and impossible to cover in the usual time given to Industrial Arts in the junior high school. However, the list may be used as a part of a general metal shop, or any of the units may be used separately as a basis for a unit shop in the senior high school.

The teacher should select from this list only those learning experiences which fit his objective, time schedule, equipment, and grade level taught.

UNIT A: FOUNDRY[1]

1. Make and pour a sand mold using a solid pattern[2] (flat-back).
2. Make and pour a sand mold using a solid pattern with irregular parting line (coped-out mold).
3. Make and pour a sand mold using a split pattern.
4. Make and pour a sand mold using a plaster of Paris match plate.
5. Make and bake a dry-sand core.
6. Make and pour a sand mold using a dry-sand core.
7. Visit a foundry.

[1] The words *foundry and founding* are both used to describe the process.

[2] The making of patterns will be covered in Unit E, Patternmaking.

UNIT B: FORGING

1. Build and maintain a forge fire
2. Draw out stock
   a. square to round
   b. round to square
   c. square to octagon
   d. octagon to round
3. Bend stock
   a. curved
   b. angular
4. Twist stock
5. Upset stock
6. Shrink stock
7. Punch stock
8. Cold-cut stock
9. Hot-cut stock
10. Fuller stock
11. Swage stock
12. Weld stock
    a. lap weld
    b. fagot weld
    c. butt weld
13. Reshape tools
    a. punches
    b. chisels
    c. picks
14. Visit a forge shop

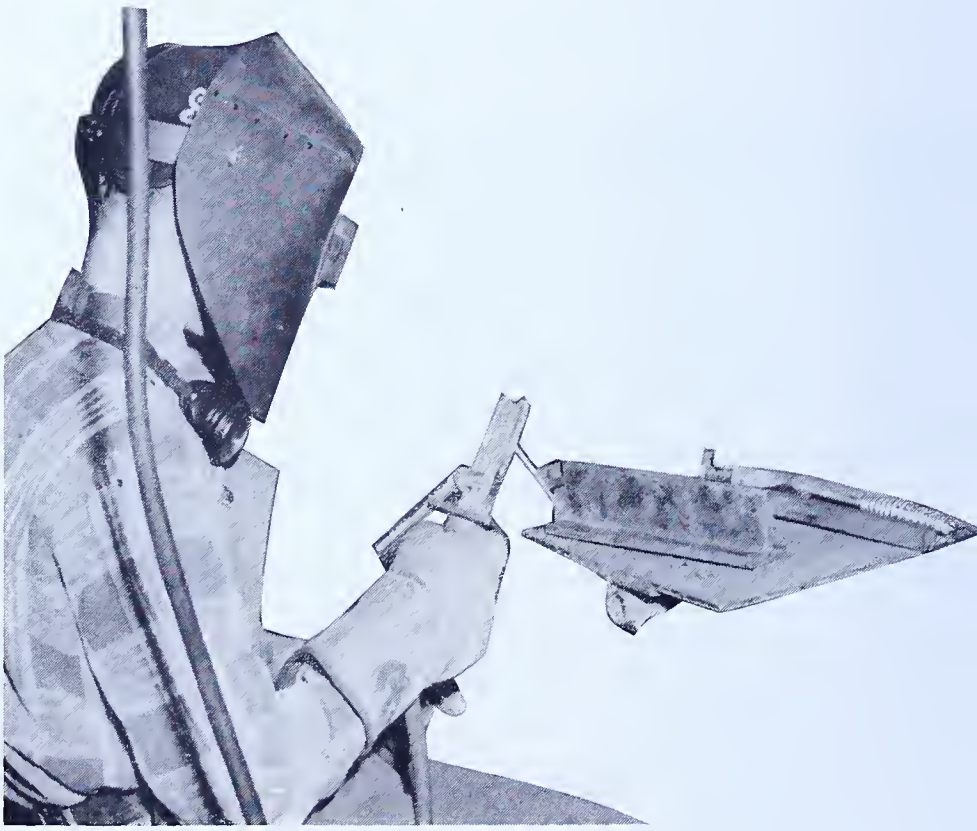
Note: Heat treatment of metals will be covered in Unit D, Heat Treatment.

UNIT C: WELDING

Oxyacetylene Welding

1. Set up an oxyacetylene welding unit
2. Properly regulate oxyacetylene pressure
3. Ignite, adjust flame to neutral, and extinguish oxyacetylene torch
   a. adjust flame to oxidizing and reducing
   b. prepare light steel plate and make puddles from each of three flames in flat position
   c. prepare light steel plate and make:
      ripple welds, forehand and backhand techniques in flat position; control puddle without rod
      bead welds, forehand and backhand techniques in flat position; control puddle with rod
4. Prepare light steel plate and oxyacetylene weld in flat position
   a. plain butt joint
   b. corner joint
5. Prepare heavier steel plate and oxyacetylene weld in flat position
   a. single "V" butt joint
   b. double "V" butt joint
   c. plain "T" joint
   d. double bevel "T" joint
   e. corner joint
   f. edge joint
   g. tack weld
6. Prepare steel plate and make: bead welds, forehand and backhand technique in horizontal position
7. Prepare steel plate and horizontal oxyacetylene weld
   a. tack weld
   b. plain butt joint
   c. corner joint
   d. single "V" butt joint
8. Prepare steel plate and make:
   a. ripple welds, forehand technique in vertical position; control puddle without rod
   b. bead welds, forehand technique in vertical position; control puddle with rod
9. Prepare steel plate and vertical oxyacetylene weld
   a. tack weld
   b. plain butt joint
   c. corner joint
   d. single "V" joint
10. Prepare steel plate and make:
    a. ripple welds, forehand technique in overhead position; control puddle without rod
    b. bead welds, forehand technique in overhead position; control puddle with rod

11. Prepare steel plate and overhead oxyacetylene weld
    a. tack weld
    b. plain butt joint
    c. corner joint
    d. single "V" joint
12. Prepare an oxyacetylene weld
    a. cast iron
    b. bronze
    c. copper
    d. aluminum
    e. pipe
13. Test welds
    a. visual inspection
    b. bend at joint
14. Set up an oxyacetylene cutting unit
15. Properly regulate oxyacetylene cutting unit
16. Ignite, adjust, and extinguish oxyacetylene cutting unit
17. Cut a piece of steel plate using oxyacetylene cutting unit
18. Cut a piece of steel pipe using oxyacetylene cutting unit



Electric Arc Welding

1. Set controls of machine for correct current and voltage
2. Strike an arc and run short beads
3. Run a straight bead of uniform width and height in three directions
4. Practice several types of weaving
5. Practice padding
6. Tack and fillet weld, lap joint, two pieces of steel plate in flat position
7. Tack and groove weld, butt joint (two pieces of steel plate in flat position) using:
   a. plain joint
   b. single "V" joint
   c. single "U" joint
   d. double "V" joint
8. Tack and fillet weld, "T" joint (two pieces of steel plate in flat position) using:
   a. plain "T" joint
   b. double bevel joint
9. Test welds
   a. visual inspection
   b. bending
10. Tack and fillet weld, lap joint, two pieces of steel plate in horizontal position
11. Tack and groove weld, butt joint (two pieces of steel plate in horizontal position) using:
   a. plain joint
   b. single "V" joint
   c. double "V" joint
12. Test welds
   a. visual inspection
   b. bending
13. Tack and fillet weld, lap joint, two pieces of steel plate in vertical position
14. Tack and groove weld, butt joint (two pieces of steel plate in vertical position) using:
   a. plain joint
   b. single "V" joint
   c. double "V" joint

15 Test welds
   a. visual inspection
   b. bending
16. Tack and fillet weld, lap joint, two pieces of steel plate in overhead position
17. Tack and groove weld, butt joint (two pieces of steel plate in overhead position) using:
   a. plain joint
   b. single "V" joint
   c. double "V" joint
18. Test welds
   a. visual inspection
   b. bending
19. Prepare and arc weld:
   a. cast iron
   b. pipe
20. Cut a piece of steel plate using electrodes
21. Cut a piece of steel pipe using electrodes
22. Visit a welding shop

UNIT D: HEAT TREATMENT

1. Ignite, adjust, and extinguish heat-treatment furnace
2. Harden a piece of tool steel using eye-judgment test for correct temperature
3. Harden a piece of tool steel using common needle-magnet test for correct temperature
4. Harden a piece of tool steel using pyrometer for correct temperature
5. Temper (draw) a piece of tool steel using eye-judgment test
6. Temper (draw) a piece of tool steel using pyrometer
7. Furnace anneal a piece of hardened tool steel
8. Box anneal a piece of hardened tool steel using lime, clean cast-iron chips, asbestos, or insulating mica
9. Normalize a piece of tool steel
10. Surface-harden a piece of low-carbon steel using a nonpoisonous surface-hardening compound
11. Carburize (pack-harden) a piece of low-carbon steel
12. File-test a piece of hardened steel using old file method

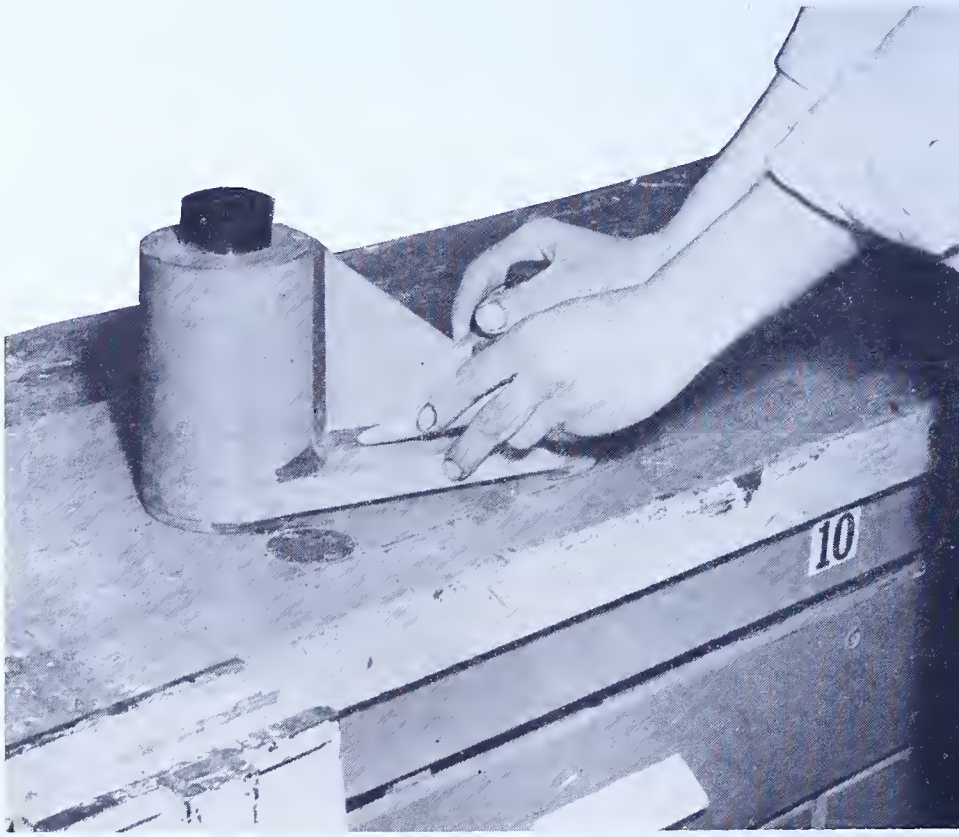
13. File-test a piece of tempered steel using old file method
14. Harden and temper a cold chisel that has been reshaped
15. Anneal a piece of aluminum that has been cold-worked
16. Anneal a piece of brass that has been cold-worked
17. Anneal a piece of copper that has been cold-worked
18. Spark-test a series of steels whose spark characteristics are known
19. Blue a tool (chisel or screw driver)
20. Clean and slush a tool
21. Visit a heat-treatment shop

UNIT E: PATTERNMAKING[1]

1. Make a simple, solid, flat pattern
2. Make a simple pattern with a greensand core
3. Make a simple split pattern (rectangular or irregular in shape)
4. Make a simple split pattern (cylindrical in shape)
5. Make a simple plaster of Paris match plate

[1] A unit in bench and machinery woodworking should precede this unit in patternmaking.

6. Lay out and make a template
7. Form surfaces using a template
8. Make a pattern with a vertical dry-sand core print
9. Color core prints and core outlines
10. Number a pattern and core box
11. Apply wood, wax, or leather fillets
12. Shellac a pattern
13. Use and care for brushes (glue, shellac)
14. Make a simple segmented pattern
15. Make a pattern with a horizontal dry-sand core print
16. Make a pattern with loose pieces
17. Visit a patternmaking shop



UNIT F: COLD FORMING

1. Read a working drawing
   a. shape description
   b. size
   c. materials
2. Plan working procedure—sequence of operations
3. Make a bill of material
   a. sizes for flat stock: thickness, width, and length
   b. sizes for round stock: diameter and length
   c. sizes for square, hexagon, and octagon stock: distance across flats and length
4. Check type, size, and amount of materials received
5. Measure metal for cutting
   Tools required—rule, scribe, circumference rule, and combination square
6. Make layouts on metal
   Tools required—combination square, scriber, dividers, calipers, hermaphrodite calipers, center punch, prick punch, surface gauge, surface plate, and V-blocks
7. Cut metals
   Tools required—hand hacksaw, tinners snips, cold chisel, and bolt cutter
   Machines required—metal cutting band saw, power hacksaw, and power shears
8. Decorate surfaces of metal
   a. natural finish—polished or dull
   b. ball-peen finish—controlled spot, close pattern
   c. cross or straight peen finish
   d. steel stamp finish
9. Shape ends of metal
   a. flatten, saw, and file to different shapes—spear, fan tail, oval, half-round, or square
   b. combine flattened ends and shaped ends
10. File metals—straight and draw
11. Grind metals
    a. observe safety rules at the grinder
    b. use proper wheel for operation
    c. learn correct tool rest adjustment
    d. hold work properly

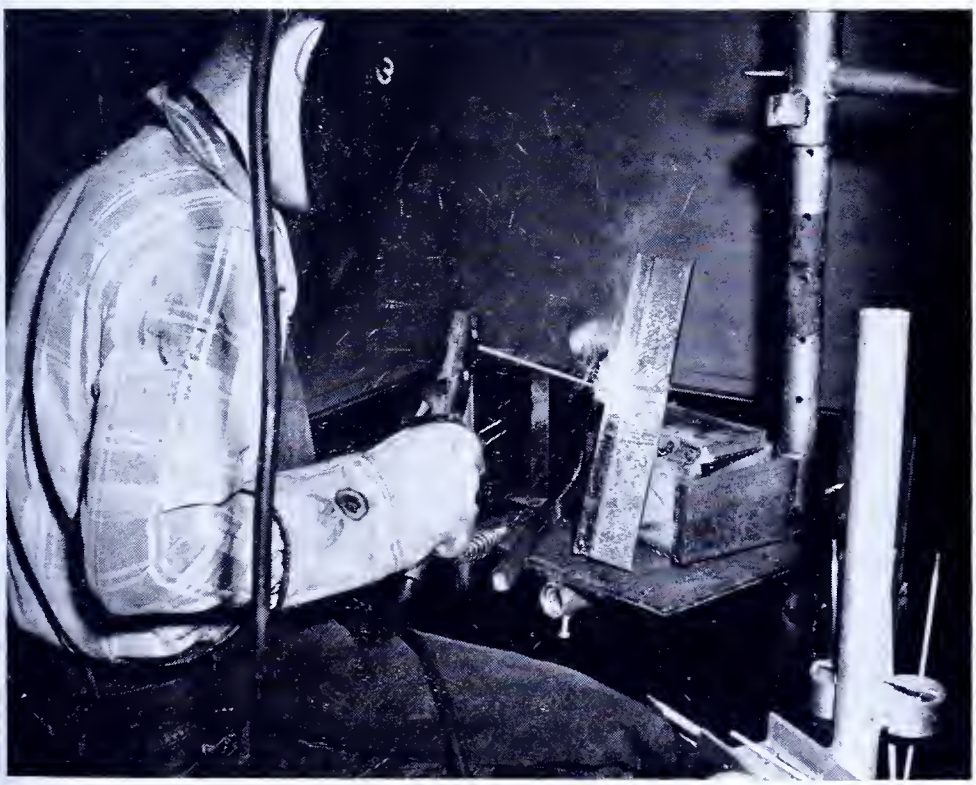
12. Make angular bends—use lever device and vise
13. Make circular bends
    a. eyes and hooks—use round forming irons
    b. large circles—use metal or wood disks
14. Make scroll
    a. full size pattern on paper—figure length of stock
    b. bending jig or bending fork—curves smooth and graceful
15. Twist metal
    a. vise and wrench for short twist
    b. pipe over metal for long twist
16. Drill metal
    a. lay out centers
    b. select proper size drill
    c. hold work properly for drilling
    d. observe safety features
    e. sharpen drills
    f. countersink
17. Thread metal
    a. use die for external threads
    b. use tap for internal threads
    c. note tap drill sizes
    d. observe care in tapping
    e. match taps and dies (types of threads)
18. Fasten metal
    a. rivet metals together—round heads for decoration, and countersink for flush finish
    b. drill for bolts or pins
19. Finish metal
    a. heat finish—polish and obtain colors; oil and smoke finish
    b. color with acids
    c. polish finish—using emery cloth and steel wool, buffing wheels and compounds
    d. use other methods of finishing—clear lacquer, enamels, flat black, bronze powders on wet undercoat, paints floated in water
20. Evaluate work for craftsmanship, beauty, and usefulness

3 Learning Units

THINGS TO Know

In Organizing and Establishing a comprehensive Metal Forming area to meet the nonmanipulative values and outcomes of Industrial Arts Education, a teacher must allot time for instruction in the technical knowledge needed for the manipulative skills, consumer values, planning, guidance, safety and hygiene, and trips to industry.

Things pupils need to know about industrial tools, materials, and processes are not all presented in the "doing" experiences of school shopwork. For example, to know the importance of the Foundry in the Metalworking Industries; to know what "temper color" to apply for a given tool; to know how mass production of drop forgings is accomplished cannot be a "doing" experience in the school shop. These



and many other experiences become the "knowing" experiences of the course, and are best taught through demonstrations, lectures, or information sheets.

The following list of "Things To Know" are suggested for use in planning a Metal Forming area of instruction. The list is divided into the six units making up the Metal Forming area: foundry, forging, welding, heat treatment, patternmaking, and cold forming.

The teacher will select from this list only those "knowing" experiences which correlate with the "doing" experiences and which fit his objective, time schedule, equipment, and grade level taught.

GENERAL INFORMATION RELATING TO METAL FORMING

1. A comprehension of occupations and employment opportunities identified with the Foundry, Forging, Welding, Heat Treatment, Patternmaking, and Cold Forming industries

2. Know the importance of the foundry, forge, welding, heat treatment, patternmaking, and cold forming in the metal working industries

3. Technical terms, correct name, safe use, and care of tools and equipment used in
   a. Foundry
   b. Forging
   c. Welding
   d. Heat treatment
   e. Patternmaking
   f. Cold forming

4. Mass production methods used in modern Metal Forming

UNIT A: FOUNDRY

KNOW—

1. Products of the Foundry
   a. Ferrous metals
      cast iron
      gray iron
      malleable iron
      steel
      carbon alloys
   b. Nonferrous metals
      aluminum
      brass
      bronze
      Monel
      tin
      magnesium
      solders
      fusible alloys
      pewter

2. Foundry sands
   a. Qualities of good molding sand for heat resistance, plasticity, bonding strength, and permeability
   b. Differences between fine- and coarse-grained sand, and where used
   c. Why sand is tempered by adding water

3. How molds are made and purpose of ramming, venting, gating, reinforcing, facing, parting, risers, and binders

4. Purpose of cores and how they are made

5. Kinds of patterns used in the foundry—solid, split, match plate, gated, and cored

6. Steps in making sand molds using:
   solid and split patterns, plaster of Paris match plate, and pattern with dry-sand core

7. Pouring temperatures, and how they apply to:
   lead, tin, zinc, aluminum, brass, bronze, cast iron, and steel
8. Why and how castings shrink; action of molecules
9. Use of fluxes
10. Melting furnace operation
11. How metal is poured safely from crucible and from ladle
12. Time required for the "freezing" of various cast metals
13. Why and how castings are cleaned and finished

UNIT B: FORGING

KNOW—

1. Why certain items are made by forging
   a. Ornamental ironwork
   b. General blacksmithing products
2. How to care for a forge fire
   a. Fuel used and why
   b. Why coke is necessary
   c. How banking holds the fire
   d. Why cleaning is important
3. How to select and fit tongs to the work
4. How to heat work
   a. Where to place in fire and why
   b. How to prevent scale formation
5. How to judge the working temperature of:
   a. Wrought iron
   b. Machine steel
   c. Tool steel
6. How to place work on anvil for:
   a. Drawing square or round
   b. Bending
   c. Upsetting by ramming or hammering

7. How to weld metals on a forge
    a. Heat necessary
    b. How to use fluxes
    c. How to make a scarf

UNIT C: WELDING

Know—

1. Why welding is used for joining metals in repairing and fabricating, and why it is used for cutting
2. Welding processes and how they differ: electric arc, oxyacetylene, thermit, and electric resistance
3. How to select welding wire and electrodes by size, A.W.S. electrode classification, and color marking identification
4. When to use bare or coated welding wire and electrodes
5. Kinds and uses of arc welding electrodes
    a. Mild steel
    b. High-tensile steel
    c. Light-gauge steel
    d. Stainless steel
    e. Cast iron
    f. Aluminum
    g. Bronze
    h. Hard-surfacing
    i. Tool-surfacing
6. Kinds and uses of oxyacetylene welding wires
    a. Mild steel
    b. High-test steel
    c. Cast iron
    d. Bronze (for brazing)
    e. Aluminum
    f. Phosphorous copper
    g. Composite hard
7. Purpose, kind, and use of fluxes
8. The chemical compositions of carbon and alloy steels by A.I.S.I. and S.A.E. numbers
9. The characteristics and application of carbon and alloy steels through S.A.E. iron and steel specifications
10. How to set-up, regulate, ignite, adjust, and extinguish the oxyacetylene welding torch and the oxyacetylene cutting unit

11. How to adjust the electric arc welding machine controls for correct current and voltage

12. How to prepare metal for welding—cleaning, positioning, and edge preparation

13. Kinds of joints used in welding
    a. Butt joint—plain, single "V", double "V", single "U"
    b. Lap joint
    c. T-joint—plain and double bevel
    d. Corner joint
    e. Edge joint
    f. Tacked joint

14. Types of welds and their uses
    a. Bead
    b. Groove
    c. Fillet
    d. Plug-slot

15. How to hold and manipulate the oxyacetylene welding torch and wire for:
    a. Types of bead
    b. Plan of weave

16. How to hold and manipulate arc welding electrodes for:
    a. Types of bead
    b. Plan of weave

17. The positions for welding
    a. Flat
    b. Horizontal
    c. Vertical
    d. Overhead

18. The methods of testing welds
    a. Penetration
    b. Bending

19. Reasons for defects in welding
    a. Unevenness
    b. Poor fusion at joints
    c. Holes in joints—porosity
    d. Brittleness
    e. Hole at end of joint
    f. Excessive metal under joint—burn through

20. Correct procedure for oxyacetylene welding
    a. Light sheet metal
    b. Cast iron
    c. Heavy steel plate
    d. Bronze
    e. Copper
    f. Aluminum
    g. Pipe
    h. Steel tubing
21. Correct procedure for arc welding
    a. Light sheet steel
    b. Cast iron
    c. Heavy steel plate
    d. Pipe

UNIT D: HEAT TREATMENT

KNOW—

1. How to understand the chemical compositions of carbon and alloy steels by the use of A.I.S.I. (American Iron and Steel Institute) and S.A.E. (Society of Automotive Engineers) systems of steel classification
2. How to understand the characteristics and application of carbon and alloy steels by using S.A.E. iron and steel specifications
3. How to understand the physical properties of carbon and alloy steels through the use of hardness values and tensile strength tables
4. Why alloys are put in tool steel
5. The purpose of hardening steel and when to quench by water, oil, or brine
6. The purpose of annealing steel and when to cool by furnace, air, or box method
7. The purpose of normalizing steel and when to cool by air or oil quench
8. The purpose of carburizing steel and when to use solid, gas, or liquid carburizers
9. How to treat steel after carburizing and when to quench by water, oil, or brine
10. The reasons for tempering (drawing) steel; the temperature range; the length of time; and the quenching

11. The purpose of nitriding; how nitrogen is introduced into steel; the temperature for nitriding; and the advantages of nitriding

12. How to determine heat colors by the use of eye judgment, needle magnet, and pyrometer

13. How to determine temper colors by using eye judgment and pyrometer

14. The types of heat-treatment furnaces; the advantages and disadvantages of oil, gas, and electric-fired furnaces

15. How the hardness of steel is tested by the use of file, Sclerescope, Brinell, Monotron, Vickers, and Rockwell hardness testers

16. The methods and procedures in metal cleaning by: tumbling, sand blasting, brushing, burring, and degreasing

17. How and why metals are colored by: organic dyes, inorganic salts, chemicals, and electrochemical methods

18. How metals are protected by using: hot oil compounds, waxes, and soap greases

UNIT E: PATTERNMAKING

KNOW—

1. How to prepare available articles for use as patterns to cast duplicates

2. The kinds of patterns used for making molds
   a. Wood
   b. Metal
   c. Plasters
   d. Plastics

3. How to select lumber for pattern construction—kinds, grades, seasoning

4. How pattern allowances are provided for:
   a. Metal shrinkages
   b. Distortion
   c. Machine finishes
   d. Draft
   e. Coreprints
   f. Shake
   g. Direction of wood grains in adjacent pieces

5. How to make templates from a drawing by transferring dimensions and shapes

6. How and when to use various pattern joinery
    a. Butt joint
    b. Cross-lap joint
    c. End-lap joint
    d. Miter joint
    e. Rabbet joint
    f. Dado joint
    g. Tongue and groove joint
    h. Dowel joint
7. How to secure parts by:
    a. Glue
    b. Nails
    c. Screws
    d. Corrugated fasteners
    e. Dowels—metal and wood
    f. Pinch dogs
8. When to use and how to make:
    a. Split patterns
    b. Segmented patterns
    c. Core boxes
    d. Loose pieces
    e. Balanced cores
9. How to finish patterns by: sanding, coloring, and shellacing
10. How to use the shrink rule
11. How to interpret patternmaking symbols
12. The standard practices in coloring patterns to indicate purpose and use
13. The method of calculating relationship of pattern weight to finished casting

UNIT F: COLD FORMING

KNOW—

1. Why certain utilitarian and decorative objects are best made by the cold forming process
2. What metals are best to use in cold forming a project from: band iron, mild-steel welding rod, sheet steel, copper sheet, wrought iron, black-sheet steel, bronze rod, tubing, soft iron wire
3. Procedure to follow to match:
    a. A full-sized drawing
    b. A partial-sized drawing
4. How to bend and shape metal parts
5. How and why to clean black iron with sulphuric acid

6. How to determine lengths of stock needed by using soft wire bent to project shapes, then straightened for measuring
7. When to use stakes and bending jigs
8. Why sharp bends are impossible when using tubing
9. How to twist square iron bars
10. How to decorate surfaces with ball peen hammer, chisel, buffer, or special tools
11. When to file, sand, or buff surfaces
12. What fastening devices to use and advantages and disadvantages of each
    a. Rivets
    b. Screws
    c. Bolts and nuts
    d. Welding
13. How to select and use the correct tools for the operation at hand: hacksaws, drills, files, grinders, tap and die sets, polisher and buffer, chisels, countersinks, punches, combination square, hammers, etc.

4 Organization of Instruction

INSTRUCTIONAL MATERIAL AND DEVICES

In Metal Forming, as well as in other areas of instruction in Industrial Arts education, instruction is built around shop projects which teach what a boy or girl should know about Metal Forming, and what he or she should be able to do.

Project Selection

Beginning projects should have a few basic learning units, selected by the teacher and required of all pupils as standard assignments. Such assignments are necessary in order to get the class under way without delay and confusion. Subsequent projects should include new learning units and should provide practice in the old. As pupils advance in knowledge and skills, they should be permitted to select their own projects with the advice of the teacher. Pupils should choose from a group of approved projects after they have mastered

fundamental tool and machine processes and have acquired sufficient experience to make wise selections. Final approval of the selection should rest with the teacher.

In order to conform to standards, all projects should:

1. Contain most of the learning units desired
2. Be simple enough to be in the range of the pupil's ability, yet difficult enough to challenge his resourcefulness
3. Be of such nature that they can be handled under school shop conditions
4. Embody good design and have some intrinsic value to the home, school, or community
5. Be of such character that they can be completed within a reasonable or specified time
6. Have value in the pupil's estimation

The teacher should carefully analyze each selected project, making a list of the learning units and a list of the best sequence of operations. Such an analysis should contain page reference to books, information sheets, study guides, and other helpful resources. Points at which the work will be checked by the teacher should be indicated.

Instructional Material

The Industrial Arts teacher of a comprehensive shop program is confronted with many problems that have to do with the administration of the program, details of instruction, and the handling of supplies. The problems increase as the activities in the shop become more diversified.

Industrial Arts teachers must, therefore, delegate certain responsibilities to student personnel, and use information sheets, project assignment sheets, operation sheets, project record cards, and progress charts.

When shop work was first introduced into the public schools, teachers had a feeling that it provided a means of escape from the "drudgery of books" for pupils who disliked reading. Therefore, little use was made of written materials. In recent years, however, because of enriched programs including more than one activity, as well as the forward strides made in the writing and publishing of well-written materials, Industrial Arts teachers are using this material advantageously. Some of the advantages of using written material are:

1. It gives the teacher more time for selecting instructional material and arranging it in the best learning order
2. It makes more accurate instructions possible
3. It places more responsibility on the student through use of reference materials
4. It lends itself to accurate record-keeping and checking
5. Larger classes can be handled more effectively
6. It gives the teacher more time for individual help

Teachers should not allow instruction sheets to take the place of personal instruction and demonstrations. The main purpose of any instructional aid is to relieve the teacher in a shop having several activities in progress at the same time. Such aids should not replace the personal contact of teachers with pupils.

Information Sheets (see sample, page 28) present selected information on materials, manufacturing processes, sources, etc., which are closely related to the activity taught. Although such sheets are available on many subjects, it is sometimes necessary for teachers to prepare their own information sheets on subjects that cannot be obtained in printed form.

Project Assignment Sheets (see sample, page 29) are concerned primarily with directing the student to a particular project. This sheet presents the project in its entirety, showing steps in procedure and listing references that describe the operation or process. Where adequate reference material is not available, the term "demonstration" is inserted to indicate that the procedure is to be demonstrated. Check points can be noted on this sheet informing the pupil where he must check his progress with the teacher before going on with the project. Using these sheets, the individual pupil can progress at his own speed and the teacher can feel certain that each student has had experiences in the most important of the manipulative activities. The use of the project-assignment sheet is helpful also in getting the entire class started with a minimum of confusion. As the class advances in knowledge and skills, the project-assignment sheet should be so modified that the pupil can eventually prepare his own project-assignment sheet after securing the teacher's approval on a project of his own choice. A skeleton form (mimeographed or printed) should be provided by the teacher to maintain uniformity.

Teachers of Metal Forming are encouraged to seek adequate instructional material covering not only the "Doing Units" but the "Knowing Units" as well. Adequate texts and study guides are listed in the annotated bibliography on pages 37 through 44.

SAMPLE INFORMATION SHEET

UNIT: *Heat Treatment*

SUBJECT: *Annealing Metal*

REFERENCES:

1. Johnson, Carl G., *Metallurgy,* Page 198.
2. Delmar Publishers, *Heat Treatment of Metals,* Page 3.

INFORMATION SECURED FROM REFERENCES:

Annealing is a process used to soften metal. The process generally consists in heating the metal to or beyond the critical temperature, followed by slow cooling. Annealing temperatures range from 1300 to 1650 degrees Fahrenheit, depending upon the carbon content of the steel and the purpose for which it is annealed.

Steel is annealed for several reasons: to induce softness; to remove strains; to alter ductility, toughness, magnetic, or other physical properties. Tool steel purchased in bar stock is generally annealed and requires no further processing prior to machining or heat treatment.

To anneal tool steel, the pieces should be packed with a carbonaceous material in well-sealed containers and placed in a furnace. This procedure is to prevent excessive decarburization and scaling. Annealing requires slow heating from a low temperature to the proper annealing temperature, with sufficient time at the annealing temperature for the heat to penetrate to the centers of the pieces.

The pieces are then cooled slowly in the furnace. Sometimes the pieces are removed from the furnace while hot and permitted to cool in lime, insulating mica, clean cast-iron chips or other heat-retarding media.

QUESTIONS:

1. Give reasons for annealing tool steel.
2. How is scaling prevented?
3. Name three heat-retarding materials.
4. What range of temperatures is used for annealing?
5. What is a carbonaceous material?

SAMPLE PROJECT ASSIGNMENT SHEET

FOUNDRY UNIT

PROJECT NO. 1 *How to Make and Pour a Simple Mold*

Note: This first foundry project is to make a paperweight cast in lead. New words will be used which can best be understood by reference to the foundry books in the shop library. Your knowledge of italicized terms will be checked by the teacher.

TOOLS NEEDED: Shovel, riddle, draw screw, bellows, bulb sponge, rammer, sprue pin, slicks, flask, moldboard, pattern, parting compound, gate cutter, strike-off bar, bottom board.

PROCEDURE: Assemble all tools and materials listed above. Read the entire procedure before beginning the following steps:

1. *Temper* the sand by sprinkling with water and mixing with shovel. It is ready for use when a lump in the hand breaks with sharp firm edges.
2. Place the flat moldboard on the work bench.
3. Place the bottom half (drag) of the *flask* on the moldboard.
4. Position the pattern on the moldboard near the center of the flask area.
5. *Dust* the pattern lightly, riddle about one inch of sand over the pattern, and then shovel sand into the drag box. Press the sand about the pattern as you proceed and *ram* the sand about the edges of the flask and the pattern. Fill with sand until full, then *strike off* level with top. Vent the drag.
6. Lay a bottom board on the sand surface, settle into place and then holding board, drag, and moldboard firmly together, turn upside down on the bench.
7. Remove the moldboard and inspect the parting surface (check with teacher).
8. Dust parting surface and blow off excess.
9. Set the cope in place on the drag.
10. Set the *sprue pin* by forcing the blunt end about a half inch into the sand about one inch from the edge of the pattern.
11. Riddle fine sand onto the parting surface, then shovel in sand, ram into place, and finally strike off the surface. Vent the cope.
12. *Tap* the sprue pin lightly to free it on all sides; then draw it carefully from the sand. Now round off the edge of the sprue hole with the fingers to *funnel* in the molten metal.

13. Lift the cope. Gently turn it upside down and set it aside.
14. Use a bulb sponge and wet down lightly the edges of the pattern to firm the sand. Place the *draw screw* into the pattern, rap lightly, and lift the pattern out of the sand.
15. Cut a channel *(gate)* about 1/4 inch deep and 3/4 inch wide from the pattern to the sprue hole. The mold is now made.
16. Check for loose sand, broken edges, and repair if needed. (Instructor will check.)
17. Place the drag on the floor on a board and gently place the cope in position on top. Use *clamps* and *wedges* to hold the flask to the bottom board.
18. Melt lead in a *ladle* on the forge. Clean it by *skimming* off the surface. When quite hot, carefully and slowly pour the molten lead into the sprue hole until filled to the top level of the sand.
19. Cool the mold for several hours; then the flask can be removed, and the sand broken apart to reach the paperweight casting. Be sure that it is cold enough to handle. Complete the job by sawing off the gate and finishing with a file.

The Sample Pupil Project Plan below is a sheet on which a pupil may plan his work, make a sketch, listing the steps of procedure he intends to follow in making a project.

SAMPLE PUPIL PROJECT PLAN

NAME .....GRADE.....SECTION.....

PROJECT .....TEACHER APPROVAL..... DATE.....

SKETCH: Make a working sketch of the project to be made. (Project plan should allow space for sketch.)

PROCEDURE: List the principal steps in making the project, showing what you will do first, second, third, etc.

1. .....
2. .....
3. .....
4. .....
5. .....
6. .....
7. .....

REVERSE SIDE OF SAMPLE PUPIL PROJECT PLAN

BILL OF MATERIAL:

No. of Pieces	*Kind of Material*	*Name of Part*	*Thick-ness*	*Width*	*Length*	*Unit Price*	*Cost*

Shop Management Organization

As the activities presented in Industrial Arts shops are increased in number and scope, it is expedient for the teacher to assign some of the clerical, preparatory, maintenance, and other routine duties to pupils. The pupil organization will vary according to the type of activity, size of the class, age of the pupils, and the physical layout of the shop.

Valuable experiences result from a good shop management organization, as commonly recognized by experienced Industrial Arts teachers. A few of the many values are:

1. Practice in leadership and "followership"
2. Development of responsibility and a feeling of belonging to the activity.
3. Motivation of pupils' interest in industrial applications and operations
4. Assistance for the otherwise busy teacher in handling routine duties

In order to make any shop management organization successful, its importance, need, and practicability must be explained carefully to the pupils. The success of the program depends entirely upon the pupils' acceptance. The teacher should plan his presentation of the idea carefully in order to justify the value and need of such a program.

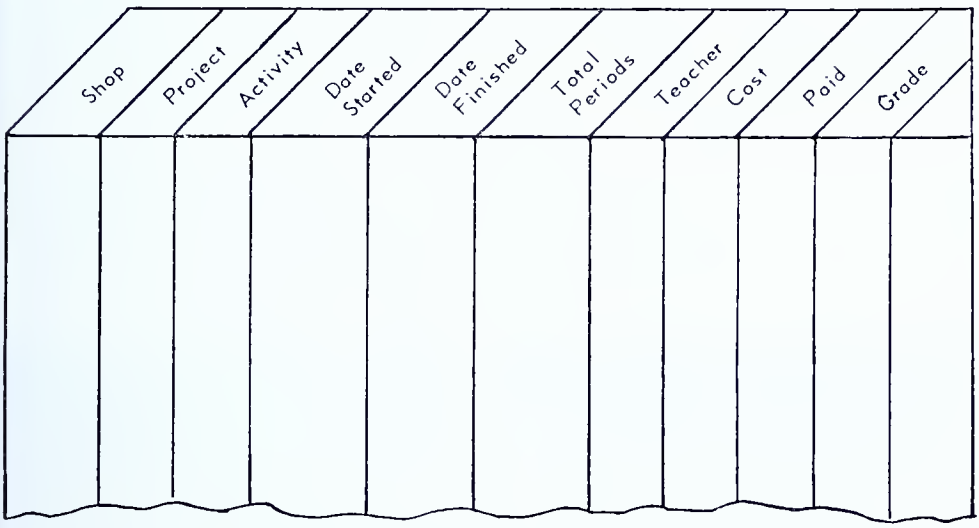
Because a teacher-imposed plan is readily recognized by the pupils, and has a tendency to lessen pupil interest, better cooperation can be developed through a personnel plan developed by the pupils with teacher guidance. A plan developed by the class or several classes motivates the pupils' interest in industrial personnel organizations, and a study of local plant systems by the pupils will be valuable in directing a well-organized plan for the school. The extra time spent in the democratic development of this plan is more than compensated by the added cooperation attained and the guidance value received by the pupils. A plan for setting up a shop management organization is given on page 83 of Bulletin 331, *Industrial Arts in Pennsylvania,* September, 1951, Department of Public Instruction.

Care should be taken that the teacher does not become so involved in the keeping of records that he actually becomes a clerk. Arrangement and filing of instructional aids may be done by the pupils.

Name Grade 7 8 9 10 11 12 PG

PUPIL CUMULATIVE PROJECT RECORD

Industrial Arts Department School City



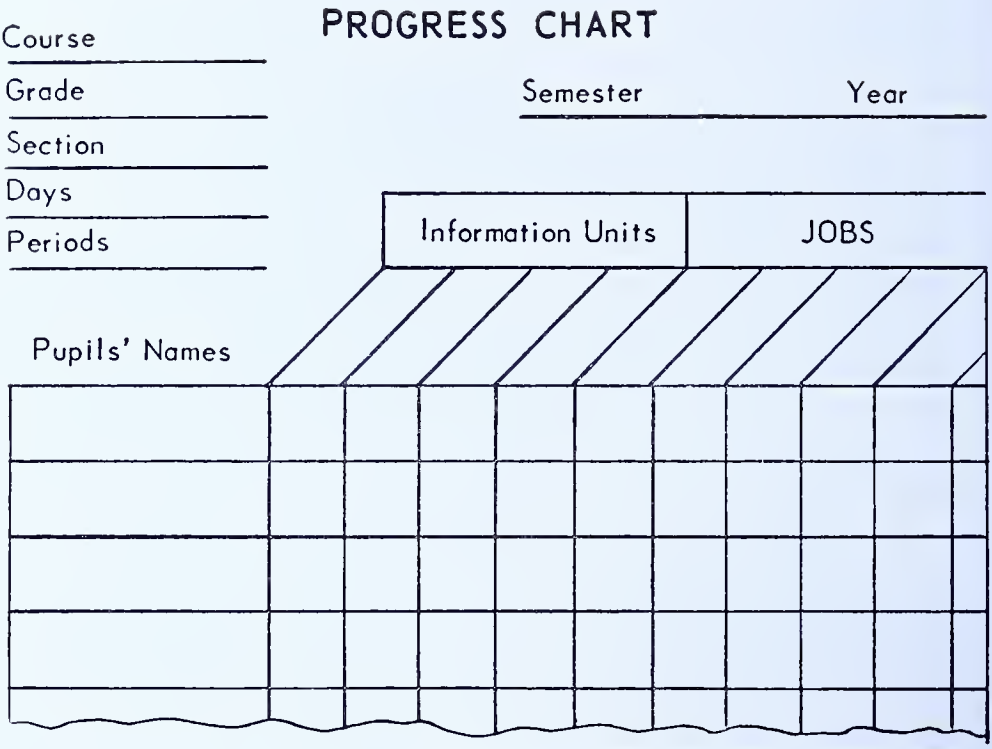
Sample of a Cumulative Project Record Form to be Kept Throughout a Pupil's School Experience in Metal Forming.

Use of Records, Forms, and Charts

The Industrial Arts teacher of a comprehensive shop program is necessarily confronted with numerous problems that have to do with the organization of the program, details of instruction, and the handling of supplies. The number of problems increases as the activities in the shop become more diversified.

Pupil Cumulative Project Record. While projects are not considered as ends in themselves but rather as means to an end, the nature and number of projects completed by the pupils are some indication of the extent to which the objectives of the course are being met. The use of this record is particularly important in the comprehensive general shop where the activities are highly diversified. A suggestive example of the Cumulative Record Form is shown above.

Progress Chart. The use of a Pupil Progress Chart is of particular importance in the operation of the activity. Since the activities taught are established through an analysis of projects, it is essential that an accurate record of each pupil's accomplishment be maintained on a progress record. A suggested progress chart is shown on page 34.



Sample Progress Chart to Show Accomplishment of Pupils Throughout the School Year.

Care in the Use of Power Machines and Other Hazardous Equipment

Safety in the school shop is everyone's job—pupils and teachers alike. If a teacher disregards the safety guards and devices on power machines, or uses unsafe working habits in foundry, forging, welding, heat treatment, and other units, posting safety rules for the pupils or teaching a course in safety will be ineffective. The Metal Forming area of a comprehensive general Industrial Arts shop can be made as safe as any other Industrial Arts area when both pupil and teacher alike adhere to a safety program which includes a safe working environment and the enforcement of safety rules.

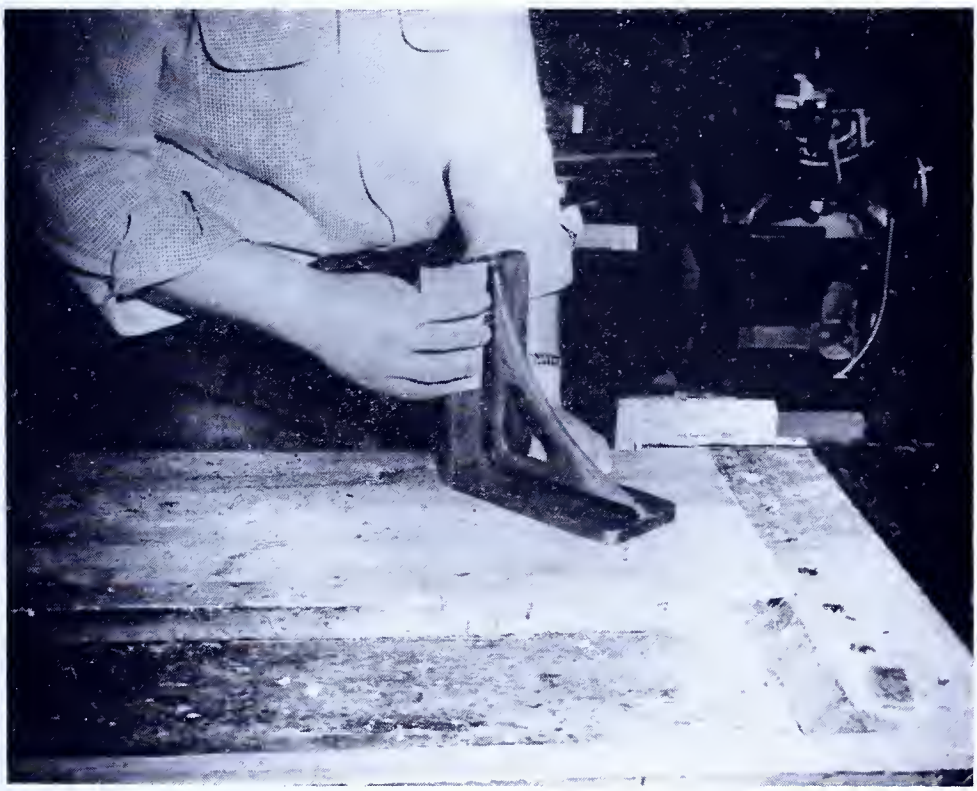
Special precautions to be observed in the different units of the Metal Forming area are:

Foundry: (1) Do not have sand too wet or pack it too hard when making a mold; (2) be sure to vent the mold; (3) do not throw damp or wet metal into molten metal; (4) always wear safety goggles when pouring molten metal, and mark all hot castings.

Forgings: (1) Make sure tool handles are tight; (2) select correct tongs for work being forged; (3) keep forge fire under control.

Welding: (1) Always wear safety goggles and shields; (2) wear gauntlet gloves and leather apron; (3) make sure all line connections are tightened; (4) when lighting torch, never point it toward person or toward anything that might be damaged by fire; (5) never raise the pressure beyond the danger point indicated on the regulator gauge.

Heat Treatment: (1) When lighting a gas furnace use lighted waste on long metal rod and stand to one side of furnace door; (2) always pick up tongs by handle end and cool the jaws before replacing in tool rack; (3) never use cyanide of potassium for surface-hardening.



A PARTIAL CHECK LIST ON CARE OF THE SHOP

This check list may be used as a guide for the teacher in keeping the Metal Forming area functioning in good order.

		Yes	*No*
1.	A place for everything and everything in its place		
2.	Tools clean, sharp, and well-maintained		
3.	Bulletin board material changed frequently, and well arranged		
4.	Planning Area material well arranged		
5.	Inflammable materials stored in approved containers and cabinets		
6.	Safety devices provided and in place		
7.	Washing facilities and drinking fountain clean		
8.	Storage provided for scrap metals, shavings, sawdust, etc.		
9.	Finishing room clean and orderly		
10.	Teacher's desk clean and orderly		
11.	Safety aisles marked and kept clear		
12.	Hot castings clearly marked		
13.	Safety goggles in good condition and in their proper places		
14.	Approved fire extinguishers in their proper places		
15.	Gas mains to the heat-treating furnace and to the foundry-melting furnace checked nightly to see that they have been turned off		
16.	Inflammable materials not permitted in vicinity of foundry, forging, welding, and heat-treatment areas		
17			
18			
19			
20			

5 Instructional Aids

BOOKS, MAGAZINES, FILMS

In a Bulletin of this size, it is impossible to list all available materials in the form of books, pamphlets, study guides, charts, and catalogs. However, an attempt has been made to list some reference materials with publisher, date, number of pages, and author. Wherever possible, an annotation of the contents is given for the convenience of the Industrial Arts teachers.

BOOKS

Bick, A. F., *Artistic Metalwork*. Milwaukee, Wisconsin, Bruce Publishing Company, 1940. 244 pp. $3.75.

Bollinger, J. W., *Elementary Wrought Iron*. Milwaukee, Wisconsin, Bruce Publishing Company, 1935. 140 pp. $2.00.

Doe, Edwin W., *Foundry Work*. New York City, New York, John Wiley and Sons, 1951. 109 pp. $1.76.

This book has been prepared in cooperation with the Textbook Committee of the Educational Division of the American Foundrymen's Society for use in high schools in teaching the simple principles of foundry practice through a series of molding problems. Contents includes: the foundry industry, fundamental foundry processes, foundry tools and equipment, patterns, sand molding, baked sand cores, melting and pouring metals and alloys, cleaning and finishing castings, occupational advantages in the foundry, glossary of foundry terms, and references and visual aids. It is illustrated with many excellent photographs and sketches.

Dragoo, A. W., and Reed, Howard O., *General Shop Metal Work.* Bloomington, Illinois, McKnight and McKnight, 1947. 104 pp. $1.25.

The five main divisions of this book are: sheet metal work, ornamental metal or band steel work, bench metal work, casting, and art metal work. Each division has *Knowing* and *Doing* units.

Feirer, John L., *Modern Metalcraft.* Peoria, Illinois, Charles A. Bennett Company, 1946. 288 pp. $3.00.

Feirer, John L., *General Metals.* New York City, New York, McGraw-Hill Book Company, Inc., 1952. 257 pp. $3.00.

This book covers all areas of general metals. It provides pupils with broad, basic experiences in the fundamentals of metalwork, and the related information needed to assist them in becoming more intelligent producers or consumers of metal products. It includes bench and sheet metal, art metal and jewelry, forging, heat treating, foundry, welding, and machine shop products. An introduction deals with general metalwork, and a final section presents suggested projects. The book contains 450 illustrations. It is suitable for use in junior and senior high schools.

Hanel, Alexander V., *Text in Patternmaking.* New York City, New York, The Bruce Publishing Company, 1950. 314 pp. $2.96.

A basic textbook providing a complete course in patternmaking. The book is divided into two parts. Part one presents information and related subjects, and tools and equipment used by the patternmaker who works in wood. Part two offers practical jobs with specific instructions in basic operations. Every important point and step in patternmaking is illustrated either with a drawing or photograph. Terms and definitions used in the pattern shop and foundry are included in a glossary at the end of the book.

Harcourt, Robert H., *Elementary Forge Practice.* Peoria, Illinois, Chas. A. Bennett Company, 1938. 182 pp. $2.80.

Problems of forgework, metal identification, and information on steel manufacturing and heat treatment are covered in detail. Processes are fully explained, supported by 38 projects that demonstrate each operation.

James F. Lincoln Arc Welding Foundation, *Plans for Making Farm Tools and Equipment.* Cleveland, Ohio. 32 pp. $.25.

A 32-page booklet of information and plans for making 25 labor-saving farm projects, including detailed drawings, bill of materials, and complete building data. Projects include: welding positioner, welding table and stool, vise stand, milk-can dolly, tool carrier, four types of trailers, two-wheeled cart, log saw, table saw, buzz saw, power cutter, two manure loaders, buck rake, three posthole diggers, grapple fork, hay loader, drill press, milk pail rack, and stile.

Johnson, Carl G., *Metallurgy.* Chicago, Illinois, American Technical Society, 1946. 418 pp. $5.00.

The basic facts on how metals behave and why. Emphasis is on physical metallurgy. The author presents the principles and practices governing the selection, testing, and treatment of metals.

Krom, Edward F., and Paige, Peter J., *Hand-Wrought Ironwork.* New York City, New York, Bruce Publishing Company, 1946. 112 pp. $2.50.

A project book of forty-seven wrought-iron articles which can be made with inexpensive materials and with few tools. The book presents a list of operations, detailed working drawings, and photographs of the finished projects.

Lincoln Electric Company, *New Lessons in Arc Welding*. Cleveland, Ohio, 1951. 312 pp. $1.00.

A series of lessons covering the fundamentals of arc welding of mild steel in all positions, and advanced lessons in alloy, sheet metal and pipe welding. The object of these lessons is to present certain fundamental facts of welding in order to teach the learner how to use the welding process successfully and economically.

The Linde Air Products Company, *The Oxyacetylene Hand Book*. New York 17, New York, The Linde Air Products Company, 1943. 600 pp. $2.70.

A handbook for the advanced student of oxyacetylene welding and cutting procedures. Over 400 how-to-do-it illustrations.

The Linde Air Products Company, *Welding and Cutting Manual*. New York 17, New York, The Linde Air Products Company, 1949. 200 pp. $1.80.

A practical, how-to-do-it book for the beginner who wants to "learn by doing." Over 600 pictures of simplified step-by-step procedures.

Lukowitz, Joseph L., *Interesting Art-Metal Work*. New York City, New York, Bruce Publishing Company, 1936. 63 pp. $1.00.

Suggested projects which are practical, attractive, inexpensive and require a comparatively short period of time to complete. No expensive hand tools or equipment are necessary to complete them. The projects require originality and initiative on the part of the pupil, and are progressively graded. This book is suggested for junior high school pupils.

McCaslin, Herbert J., *Wood Patternmaking*. New York City, New York, McGraw-Hill Book Company, Inc., 1946. 366 pp. $3.20.

How to construct wood patterns and their core boxes, and how to make sand molds. Included are sixty-four problems on bench and lathe work each presenting one or more new features. Shop practices treat on such pattern problems as match- and follow-board work, application of the cap-core, skeletonized pattern construction, core-frame setups for molds to be assembled from dry-sand core bodies. A glossary of terms covers every phase of the subject.

Palmer, Frank R., and Luerssen, George V., *Tool Steel Simplified*. Reading, Pennsylvania, Carpenter Steel Company, 1948. 564 pp. $2.00.

A book for workers in industry responsible for the design, making, or heat treating of tools. It presents simplified methods for selecting and heat treating the proper tool steel to make any kind of tool. The book is divided into five parts: Part I, Getting acquainted with tool steel; Part II, Selecting the right tool steel for each kind of tool; Part III, Properties, heat treatment, and testing of tool steel; Part IV, Things worth knowing and Part V, Helpful tables.

Petersen, L. C., *101 Metalworking Projects*. Milwaukee, Wisconsin, Bruce Publishing Company, 1929. 214 pp. $2.75.

Rigsby, Herbert P., and Groneman, Chris H., *Elementary and Applied Welding*. New York City, New York, Bruce Publishing Company, 1948. 147 pp. $2.00.

This book contains material especially adaptable to the beginning pupil in both oxyacetylene and arc welding. Basic procedures are given and are fully illustrated with photographs and sketches so that the learner is guided from the most simple to the more complicated processes involved. Informational material is restricted to industrial opportunities, commercial methods, tools and equipment, metals, and safety practices. Each project is illustrated by a photograph and working drawing and is explained by a complete project procedure. The projects have been designed to appeal to the pupil and include useful articles for the home, the school, and the home workshop.

Rusinoff, S. E., *Forging and Forming Metals.* Chicago, Illinois, American Technical Society, 1952. 279 pp. $3.95.

This book covers the following: impact, press, and upset forgings; extrusions; heat treatment of forgings; cleaning and finishing forgings; inspection; safety; the designing of forgings, and forging tools and dies.

Selvidge, R. W., and Allton, J. M., *Blacksmithing.* Peoria, Illinois, Chas. A. Bennett Company, 1925. 156 pp. $2.76.

Instructions cover the operations involved in forging and welding iron and steel, hardening and tempering, general repair work, tire setting, and horseshoeing. Forty-eight unit operations deal with manipulative operations based upon analyses of jobs. Units are divided into definite "doing" instructional steps for performing the operations. References and questions are included. Seventeen information topics deal with location of shop equipment, forge, anvil, forge fire, fuel used, blacksmith tools, iron and steel, effect of heat on steel, welding, fluxes, tempering tool steel, case-hardening, and emery wheel test for determining kinds of materials.

Simpson, W. C., and Gray, B. L., *Foundry Work.* Chicago, Illinois, American Technical Society, 1947. 216 pp. $2.10.

A practical handbook on standard foundry practices, including hand and machine processes, providing typical problems, operations, equipment, and the metallurgy of casting metals.

Smith Robert E., *Pattern Making and Founding.* Bloomington, Illinois, McKnight and McKnight, 1953. 72 pp. $1.00.

This is a revised edition of *Units in Patternmaking and Foundry.* A beginner's course with informational and operational units covering metals, the metalworking industry, and the procedures involved in making patterns and handling molten material. Many illustrations supplement the text material.

University of the State of New York, *Heat Treatment of Metals.* Albany, New York, Delmar Publishers, 1951. pp. 51. $1.30.

This book deals with the related technical information and the fundamental processes of heat treatment including a series of fifteen laboratory experiments. Contents: description of forging and forging tools; how to shape by forging; description of casehardening; how to caseharden low carbon steel; description of hardening and tempering; how to harden and temper carbon tool steel; S. A. E. system of steel classification.

University of the State of New York, *Metal Area Related Information.* Albany, New York, 1951. 146 pp. $1.95.

This manual and study guide includes a selected series of lesson topics for General Metalwork for the seventh, eighth, and ninth grade comprehensive general shop. The related lesson topics have been grouped to assist in their selection and use, and include: planning, social economics, guidance, science, safety and hygiene, and consumer values. Each topic includes an introduction, references, pupil assignment and a topical test. A bibliography contains books, catalogs, films, magazines, periodicals, manuals, pamphlets, and charts.

Van Leuven, E. P., *Cold Metalworking,* New York, New York, McGraw-Hill Book Company, Inc. 275 pp. $3.60.

Wendt, R. E., *Foundry Work.* New York, New York, McGraw-Hill Book Company, Inc., 1942. 261 pp. $3.75.

Covers general knowledge of foundry work, molding sands, dry-sand coremaking, pattern equipment, machinery used in molding departments, melting and mixing of metals, instructions for practice in molding and coremaking.

BULLETINS AND BOOKLETS

Braze-Welding, Form 9185-A. Linde Air Products Company, 30 East 42nd Street New York City 17, New York.

Fabrication of Welded Piping. Linde Air Products Company, 30 East 42nd Street, New York City 17, New York.

Fusion Welding Cast Iron, Form 5232. Linde Air Products Company, 30 East 42nd Street, New York City 17, New York.

Gas Welding and Flame Cutting, Bulletin No. 23. National Safety Council, 20 North Wacker Drive, Chicago 6, Illinois.

Heat Treating and Equipment for School, Laboratory, Small Shop. Chicago Flexible Shaft Company, 5600 Roosevelt Road, Chicago, Illinois.

How to Bronze Weld, Form 4328. Linde Air Products Company, 30 East 42nd Street, New York City 17, New York.

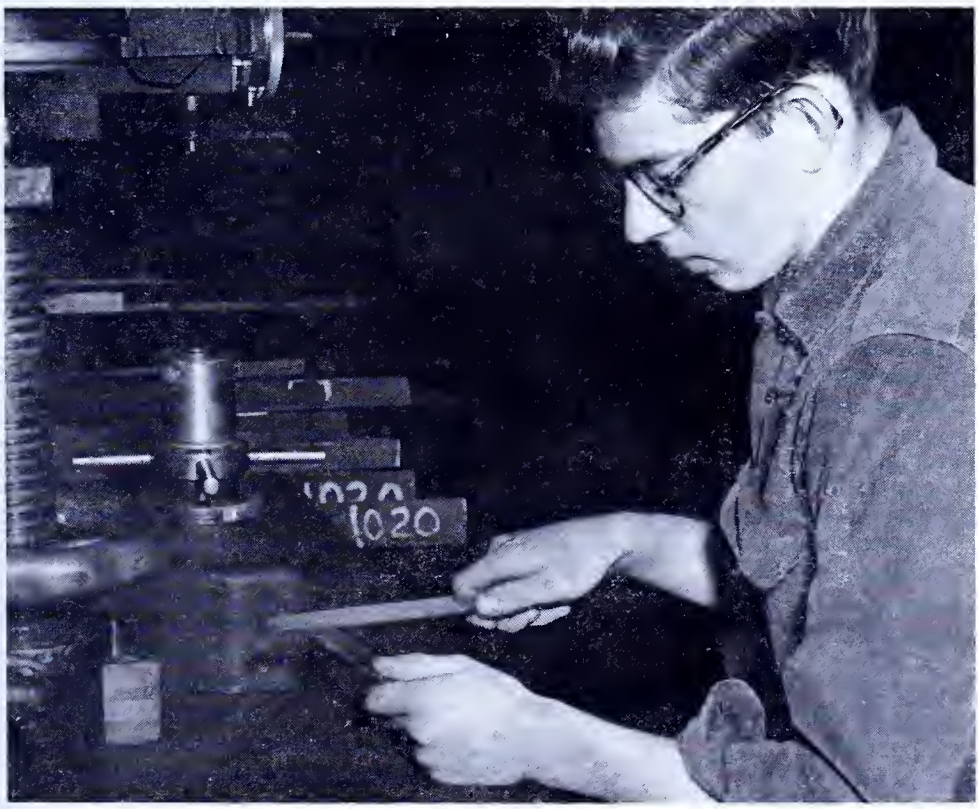
How to Repair Broken Automobile Bumpers, Form 4782. Linde Air Products Company, 30 East 42nd Street, New York City 17, New York.

How to Weld Aluminum, Form 4538. Linde Air Products Company, 30 East 42nd Street, New York City 17, New York.

How to Weld Lead. Linde Air Products Company, 30 East 42nd Street, New York City 17, New York.

Instruction Outline for Welding Steel, Form 4645. Linde Air Products Company, 30 East 42nd Street, New York City 17, New York.

Oxyacetylene Handbook. 30 East 42nd Street, New York 17, New York, Linde Air Products Company, 1943. 600 pp. $2.70.



Oxyacetylene Heating for Bending, Straightening, and Forming, Form 4200. Linde Air Products Company, 30 East 42nd Street, New York 17, New York.

Oxyacetylene Flame Work for the Farmer. Linde Air Products Company, 30 East 42nd Street, New York 17, New York.

Practical Kinks on How to Make It. Linde Air Products Company, 30 East 42nd Street, New York 17, New York.

Precautions and Safe Practices in Welding and Cutting With Oxyacetylene Equipment. Linde Air Products Company, 30 East 42nd Street, New York 17, New York.

Presto-O-Lite Air-Acetylene Appliances—How and Where to Use Them, Form 9061-C. Linde Air Products Company, 30 East 42nd Street, New York 17, New York.

Safe practices in Handling Compressed Gases, Bulletin No. 95. National Safety Council, 20 North Wacker Drive, Chicago 6, Illinois.

Safe Practices in the Foundry. National Safety Council, 20 North Wacker Drive, Chicago 6, Illinois.

Shop Equipment That You Can Make, Form 4971-B. Linde Air Products Company, 30 East 42nd Street, New York 17, New York.

Shop Handbook on Tool and Alloy Steels. Joseph T. Ryerson and Son, Inc., Chicago, Illinois.

Steel Hard-Facing Procedure, Form 7119. Linde Air Products Company, 30 East 42nd Street, New York 17, New York.

Tool Steel Treaters' Guide, Bulletin 148-B. Bethlehem Steel Company, Bethlehem, Pennsylvania.

Two Methods for Welding Iron Castings, Form 6328. Linde Air Products Company, 30 East 42nd Street, New York 17, New York.

Welding and Brazing Alcoa Aluminum. Aluminum Company of America, Pittsburgh, Pennsylvania.

Welding and Cutting Manual. Linde Air Products Company, 30 East 42nd Street, New York 17, New York, 1949. 200 pp. $1.80.

MAGAZINES AND TECHNICAL JOURNALS

Industrial Arts and Vocational Education. Milwaukee, Wis., Bruce Publishing Co. 10 issues a year. $3.00.

Foundry, The. Cleveland, Ohio, Penton Publishing Co. Monthly. $5.00.

Metal Treating. New Rochelle, N. Y., Metal Treating Institute. Bimonthly. Free.

School Shop. Ann Arbor, Michigan. Monthly. Free.

Welding Engineer, The. New York, N. Y., McGraw-Hill Book Company, Inc. Monthly. $3.00.

FILM SOURCES AND TITLES[1]

Add Power to Your Hands. Utica Forge and Tool Corporation, Utica 4, New York. 16 mm., sound, black and white, 10 minutes. Transportation charged both ways.

Alcoa Motion Pictures. Aluminum Company of America, 801 Gulf Building, Pittsburgh 19, Pennsylvania.

Allegheny Ludlum Films. Allegheny Ludlum Steel Corporation, 532 Oliver Building, Pittsburgh 22, Pennsylvania.

Audio-Visual Aid Catalog. Bulletin 208. Department of Public Instruction, Commonwealth of Pennsylvania, Harrisburg, Pennsylvania.

Audio-Visual Aids Library. The Pennsylvania State College, State College, Pennsylvania.

Bureau of Mines Films. Graphic Services Section, Bureau of Mines, 4800 Forbes Street, Pittsburgh 13, Pennsylvania.

Designing Machinery for Arc Welding. Lincoln Electric Company, Cleveland, Ohio. 16 mm., sound, color, 15 minutes. Transportation charged both ways.

Die Casting. Market Developing Division, The New Jersey Zinc Company, 160 Front Street, New York 7, New York. 16 mm., sound, color, 30 minutes. Transportation charged both ways.

Film Directory. American Foundrymen's Society, Chicago, Illinois.

Guide to Free Films. Educators' Progress Service. Randolph, Wisconsin. $6.00.

Magic Wand of Industry. Lincoln Electric Company, Cleveland, Ohio. 16 mm., sound, color, 25 minutes. Transportation charged both ways.

[1] Specific titles of films are italicized. All other titles indicate film sources.

Men, Metal, and Machines. Douglas D. Rothacker, 729 Seventh Avenue, New York 19, New York. 16 mm., sound, 35 minutes. Transportation charged both ways.

Metal Magic. Allis-Chalmers' Advertising Department, Milwaukee 1, Wisconsin. 16 mm., sound, 12 minutes. Transportation charged both ways.

Plastic Molding. F. J. Stokes Machine Company, Department P. E., Tabor Road, Philadelphia 20, Pennsylvania. 16 mm., sound, color, 30 minutes. Transportation charged both ways.

Prevention and Control of Distortion in Arc Welding. Lincoln Electric Company, Cleveland, Ohio. 16 mm., sound, color, 20 minutes. Transportation charged both ways.

Slidefilms and Motion Pictures to Help Instructors. Jam Handy Organization, Educational Film Department, 2900 East Grand Boulevard, Detroit 11, Michigan.

Sound Motion Pictures and Slidefilms. Westinghouse Electric Corporation, 511 Wood Street, Box 868, Pittsburgh 30, Pennsylvania.

Teaching Aids for Science, Home Economics, Vocational Agriculture, Industrial Arts. Westinghouse Electric Corporation, School Service, 306 Fourth Avenue, Box 1017, Pittsburgh 30, Pennsylvania.

This Moving World. Malleable Founders Society, Union Commerce Building, Cleveland, Ohio. 16 mm., sound, color, 30 minutes. Transportation charged both ways.

U. S. Government Films for School and Industry. Castle Films, Division of United World Films, 30 Rockefeller Plaza, New York 20, New York.

United States Steel Films. Film Distribution Center, United States Steel Corporation, 436 Seventh Avenue, Pittsburgh 30, Pennsylvania.

Welding Comes to the Farm. Lincoln Electric Company, Cleveland, Ohio. 16 mm., sound, color, 24 minutes. Transportation charged both ways.

6 Equipment and Supplies

HOW TO SPECIFY AND ORDER

In this Section the teacher of Industrial Arts will find suggestions on how to select and order hand tools, machine tools, other equipment, and consumable supplies. Suggested lists of tools, other equipment, and consumable supplies are presented for each of the six units of the Metal Forming area. These are based on an enrollment of twelve pupils per class, six classes per day, in the Metal Forming Area of a comprehensive general shop. The local Industrial Arts teacher should check these lists with the course of study to determine whether or not they include all essential hand tools, machine tools, equipment, and supplies.

How to Select Equipment

The Industrial Arts teacher frequently needs to recommend replacement of worn-out hand tools, machine tools, equipment, and supplies, or he may be consulted on the purchase of new equipment for the shop. No two schools have the same budget, physical plant, or edu-

cational program; therefore, all planning must conform with local needs and resources.

Factors to be considered in determining the quantity and type of equipment to be selected for the Metal Forming Area of a comprehensive general shop are:

1. The objectives to be attained through its use
2. The activities planned
3. The size of the class
4. Content and scope of the course
5. Whether used in junior or senior high school, or both
6. Funds available
7. Space available
8. Adequacy of safety devices
9. Flexibility; adaptation to other uses
10. Power and gas supply

How to Specify and Order Equipment

When making purchases of hand tools, machine tools, other equipment, and supplies, it is essential that complete written specifications be prepared to submit to distributors for bidding purposes. Industrial Arts teachers should consult manufacturers' catalogs so that when orders are written the supplier or bidder will know exactly what is wanted.

Each item on the specification or order sheet should list all necessary information. Items should be listed uniformly and contain the following:

1. Item number
2. Quantity desired
3. Unit of measure
4. Catalog number
5. Name of item
6. Complete description of item

Specifications should ordinarily be written for a specific piece of equipment which comes closest to the teacher's requirements. In this case write the words "or equal" following the item, or include the phrase in the "Instructions to Bidders."

Specifications should be written in the form suggested below:

1. 1, forge, steel, hearth-type, 24″ diameter x 3″ depth, half-hood, height 30″, weight 80 lbs., enclosed base of cold-rolled steel, 20-gauge, with bottom rolled and spot-welded to side plates, hand-operated blower.

2. 2 pr. goggles, flash, shade 3.
3. 1 shrink rule, steel, 12 inches long, 1/4" shrink
4. 500 pounds, molding sand, Albany 00

Storage and Control of Tools, Supplies, and Projects

The storage and arrangement of the tools depend largely on the physical layout of the shop, types of activities, size of class, available funds, and the ease with which the tools can be checked at the end of the shop period.

Present trends are away from the traditional toolroom in favor of the open tool panel. The tool panel is fastened to the wall and contains tools normally used in the particular work area. The panel has a light background on which is painted a silhouette of each tool. This method of storage saves time for the pupil in obtaining and returning tools, eliminates congestion in the central toolroom, and facilitates the teacher's task in checking tools. Additional suggestions on tool control can be found in *Industrial Arts in Pennsylvania,* Bulletin 331, Department of Public Instruction, pages 91-93.

Providing storage space for consumable supplies is an important factor in the planning of building facilities for Industrial Arts education. The comprehensive general shop ordinarily requires a dry and well-lighted room for storage of supplies and projects. Racks should be provided for the storage of lumber and metal. Miscellaneous supplies can be stored in metal storage cabinets. Bins and shelves should be provided for the storage of unfinished jobs. In small shop areas additional storage space can be secured by using work benches with locker-type bases.

How to Keep an Inventory

Many different methods of keeping an inventory are used in Industrial Arts shops. The type used depends somewhat on the local school organization. In larger systems, methods of keeping inventories are set up by the administrative office. In smaller systems, however, the job of keeping inventory falls on the individual teacher. Although there are many advantages in keeping an accurate inventory, only a few of the more important ones are listed here.

The inventory form

1. Provides a periodic check on the condition and quantity of tools
2. Tells at all times the quantity of stock and supplies on hand

_____ High School

_____ School District

INVENTORY OF METAL FORMING SHOP

Instructor_____ School Year_____

Received	EXPENDED				On Hand at End of Term—1952-53	Ordered for Term—1953-54	Description of Items	Unit Cost	Total Cost
	Broken	Worn Out	Lost	Transferred					
4	1		1		2	2	CHISEL, cold, ¾"	$.72	$1.44
5					2	3	CANS, oil, ½ pint	.60	1.80

3. Gives accurate information as to the amount that was used during the past year
4. Determines the amount needed for the next year
5. Justifies quantities on requisitions to the superintendent of schools and board of school directors

A suggested shop inventory form is shown on page 48.

Hand Tools, Machine Tools, Other Equipment, and Supplies List

The hand tools, machine tools, other equipment, and supplies recommended in this bulletin are based on the minimum requirements in the Metal Forming area for twelve pupils per class, six classes per day, in a comprehensive general shop. Where a particular manufacturer's name is specified, it should not be assumed that the product is preferred or recommended over another manufacturer's products. It is used only to illustrate needed materials and equipment.

SUGGESTED LIST OF TOOLS AND OTHER EQUIPMENT

Unit A: Foundry[1]

Number Required	*Description*	*Cost Each*	*Total[2] Cost*
2	Bellows, 10″	$ 5.14	$ 10.28
1	Bench, molding[3], 60″ x 30″ x 30″	150.00	150.00
1	Blanket, safety	10.00	10.00
	Bottom boards[3], wood		
12	8″ x 10″	3.00	36.00
4	12″ x 18″	3.50	14.00
2	Crucibles, graphite, for melting furnace, self-skimming type	14.40	28.80
	Cutters[3]		
2	gate, 1″ width	.50	1.00
2	sprue, ¾″ x 10″	1.50	3.00
2	sprue, ½″ x 10″	.90	1.80
2	spoon and gate, 1″ width	1.80	3.60
2	Draw screws[3]	.50	1.00
	Flasks		
4	metal, snap, 12″ x 18″	10.72	42.88
12	wood[3], 8″ x 10″	5.00	60.00
1	Furnace, melting, pot capacity 10 lbs. of aluminum	135.00	135.00
2 pr.	Gloves, asbestos, foundry	3.75	7.50
2 pr.	Goggles, melter's safety	2.20	4.40
1	Ladle, pouring	1.00	1.00
1 pr.	Leggings, foundry	4.35	4.35
2	Lifters, "Yankee," ⅜″ x 2″	1.95	3.90
	Mold Boards[3] wood		
2	8″ x 10″	2.00	4.00
2	12″ x 18″	2.50	5.00
1	Mold, ingot (for surplus metal)	4.25	4.25
	Patterns (as needed)[3]	———	———
1	Pyrometer, 0–2000° F., with thermocouple	30.25	30.25
2	Rammers, bench, 2½″ x 12″[3]	2.27	4.54
2	Rapping bars[3]	.50	1.00
2	Riddles, foundry, 8-mesh, 18″ diameter	1.64	3.28
2	Shields, face and eye	3.60	7.20
1	Shovel, molder's, 9″ x 12″	3.00	3.00
2	Slick and oval, 1″ width	1.80	3.60
2	Slick and square, 1″ width	1.80	3.60
1	Sprinkling can, small	1.35	1.35
2	Strike-off bars[3] (straight edge)	.60	1.20
2	Swabbers, rubber bulb, 4 oz. capacity	2.85	5.70
2	Taper and leaf, 1″ width	1.80	3.60
	Tongs		
1	crucible	4.75	4.75
1	pick-up, 24″	3.00	3.00
1	finishing, 1½″ x 6″	2.40	2.40
1	square, 1½″ x 6″	2.40	2.40
2	Vent wires	.10	.20
	Total		$612.83

[1] For two pupils a class, six classes a day.

[2] These prices are subject to fluctuation.

[3] May be made in school shop.

Unit B: Forging[1]

Number Required	Description	Cost Each	Total[2] Cost
1	Anvil, 100 lb., tool steel face	$30.80	$30.80
1	Anvil base, wood, 16″ x 16″ x 24″, elm	10.00	10.00
1	Anvil hardy, tang to fit anvil listed above	1.50	1.50
2	Aprons, shop	1.25	2.50
	Calipers		
	inside, firm joint, 8″	1.50	1.50
1	outside, firm joint, 8″	1.50	1.50
	Chisels		
1	cold-cut, 1½″, handled	3.00	3.00
1	hot-cut, 1½″, handled	3.60	3.60
1	Dividers, solid nut, 8″	2.75	2.75
1	Fire hook	.75	.75
1	Forge, steel, hearth, 24″ diameter, 3″ depth, half-hood, height 30″, weight 80 lbs., enclosed base of cold-rolled steel, 20-gauge, with bottom rolled and spot-welded to side plates, hand-operated blower	77.50	77.50
	Fullers		
1	top, ⅜″, handled	2.60	2.60
1	bottom, ⅜″, handled	2.05	2.05
	Hammers		
1	blacksmith, hand, 4 lbs., fitted with handle	2.60	2.60
1	flatter, 2″ square, handled	2.95	2.95
1	set, 1½″, handled	3.00	3.00
1	Poker	.25	.25
	Punches		
1	square, ⅜″, handled	2.20	2.20
1	round, ¼″, handled	2.20	2.20
1	round, ⅜″, handled	2.20	2.20
1	round, ½″, handled	2.25	2.25
1	Rule, steel, 2-ft., 16th graduations, 1¼″ wide	2.85	2.85
1	Scriber	.70	.70
1	Shovel, small coal	.50	.50
	Sledges, blacksmith's		
1	cross peen, 8 lb., handled	4.11	4.11
1	straight peen, 8 lbs., handled	4.10	4.10
1	Square, steel, body 24″, tongue 16″ (not rafter marked)	2.80	2.80
	Swages		
1	bottom, ⅜″, handled	2.00	2.00
1	top, ⅜″, handled	2.55	2.55
1	Swage block, cast-iron, round holes 1″, 1½″, 2″; square holes, 1″ and 2″; rectangular holes, 1″, 2″; size 10″ x 14″ x 3¾″ thick	23.50	23.50
1	Tank, quenching	5.00	5.00
	Tongs, blacksmiths		
1	for ⅜″ rounds	3.10	3.10
1	for ⅜″ squares	2.75	2.75
1	gad, 24″ length	2.90	2.90
1	pick-up, 24″ length	3.00	3.00
1	Tool rack	1.25	1.25
1	Vise, blacksmith's, 4″ jaws	22.95	22.95
	Total		$241.76

[1] For two pupils a class, six classes a day.

[2] These prices are subject to fluctuation.

Unit C: Welding[1]

Number Required	*Description*	*Cost Each*	*Total[2] Cost*
	ARC WELDING		
2	Apron, leather, size 24″ x 36″	$8.50	$17.00
1	Arc Welder, electric, D.C., 180 amp., 220 volts, 3 phase, 60 cycles	270.00	270.00
1	Booth[3], welding, steel, 5 x 5 feet, with positive exhaust system	(made to order)	
2	Brush, wire, welders	.75	1.50
2	Cable, welding, 25-ft. lengths, 200 amps., with necessary lugs .....35 ft. @	.50	17.50
	Chisel, cold		
1	½″	.50	.50
1	¾″	.80	.80
	Clamps		
1	"C", for ground cable, 8″	3.15	3.15
2	"C", 8″	3.15	6.30
2 pr.	Gloves, welders, cowhide	3.00	6.00
2 pr.	Goggles, flash, shade 3	2.25	4.50
1	Grinder, electric, 10″, 1 H.P., complete with tool rests, wheels, wheel guards, switch, and dust shields, 1800 R.P.M.	145.00	145.00
1	Hammer, chipping	1.50	1.50
1	Handshield, welding	5.65	5.65
1	Helmet, welding	7.15	7.15
1	Holder, electrode, 300 amp.	4.13	4.13
1	Pliers, combination, 8″	.78	.78
1	Table,[3] welding, steel top, 2 x 2 feet	10.00	10.00
1	Vise, bench, swivel base, 4″ jaws	30.00	30.00
	Total		$531.46

	OXYACETYLENE WELDING		
2	Clamps, "C", 8″	$3.15	$6.30
1	Cutting attachment, 90° head	25.00	25.00
	Cylinders		
1	110 cu. ft. capacity for acetylene	30.00	30.00
1	110 cu. ft. capacity for oxygen	30.00	30.00
2	Goggles, welding, shade 5	2.50	5.00
1 pr.	Hose, twin 25-ft. length, 3/16 dia. with fittings	9.00	9.00
1	Mixer	2.75	2.75
1	Pliers, combination, 8″	.78	.78
	Regulator, double gauge		
1	acetylene	25.00	25.00
1	oxygen	27.50	27.50
12	Sparklighters	.30	3.60
1	Table,[3] welding, fire brick top, size approximately 36″ x 36″ x 34″ high	45.00	45.00
	Tip, cutting		
1	size 1	3.00	3.00
1	size 2	3.00	3.00

[1] For two pupils a class, six classes a day.

[2] These prices are subject to fluctuation.

[3] May be made in school shop.

Number Required	Description	Cost Each	Total Cost
	Tip, welding		
1	2 cu. ft.	$2.00	$2.00
1	6 cu. ft.	2.00	2.00
1	12 cu. ft.	2.00	2.00
1	20 cu. ft.	2.25	2.25
1	30 cu. ft.	2.25	2.25
1	Tongs, pick-up, 24″	3.00	3.00
1	Torch, welding	18.00	18.00
1	Truck,[3] cylinder	23.00	23.00
1	Wrench, 6-way	1.50	1.50
	Total		$271.93

[3] May be made in school shop.

Unit D: Heat Treatment[1]

Number Required	Description	Cost Each	Total[2] Cost
1	Box, annealing, steel, approximately 12″ x 12″ x 8″ deep	$5.00	$5.00
1	Box, with cover, nichrome, for carbonizing, approximately 6″ x 9″ x 2½″ deep	23.25	23.25
2	Files, flat mill, smooth, 6″ long, handled	.50	1.00
1	Furnace, heat treating, gas, temperature range 300° to 1800° F., pedestal type	150.00	150.00
2	Gloves, asbestos	5.63	11.26
1	Hook, ¼″ diameter x 24″ long	.75	.75
1	Hook, ⅜″ diameter x 30″ long	1.00	1.00
2	Magnets, needle	2.00	4.00
1	Pyrometer, 0-2000° F. with thermocouple	30.25	30.25
2	Shields, face and eye	3.85	7.70
2	Tanks, quenching, steel, tinned, 18″ diameter x 24″ deep, complete with cover. Heavy duty milk can with cover may be used	11.00	22.00
1	Tongs, pick-up, 24″ length	3.00	3.00
1	Tongs, angle, pick-up, 24″ length	3.25	3.25
	Total		$262.46

[1] For two pupils per class, six classes a day.

[2] These prices are subject to fluctuation.

Unit E: Patternmaking[1]

Note: It is assumed that the tools, machines and other equipment for a unit in bench and machine woodworking are available. Only special patternmaking tools are listed here.

Number Required	*Description*	*Cost Each*	*Total[2] Cost*
	Bits, Forstner		
1	size 10	$1.65	$1.65
1	size 12	1.90	1.90
1	size 16	2.45	2.45
1 set	Carving tools, set of 6	19.25	19.25
	Chisels, paring		
1	¾", beveled edge, straight shank, handled	2.00	2.00
1	1", beveled edge, straight shank, handled	2.30	2.30
1	1¼", beveled edge, straight shank, handled	2.60	2.60
1	1", beveled edge, offset shank, handled	2.15	2.15
	Cornering tools		
1	1/16" x ⅛"	.60	.60
1	¼" x ⅜"	.60	.60
	Gouges, paring		
1	⅛", straight shank, inside-ground, full sweep, handled	3.90	3.90
1	¼", straight shank, inside-ground, full sweep, handled	3.95	3.95
1	½", straight shank, inside-ground, full sweep, handled	4.35	4.35
1	¼", straight shank, inside-ground, flat sweep, handled	3.95	3.95
1	⅜", straight shank, inside-ground, flat sweep, handled	4.30	4.30
1	½", straight shank, inside-ground, flat sweep, handled	4.35	4.35
1	¾", straight shank, inside-ground, flat sweep, handled	4.75	4.75
	Fillet Irons		
1	⅛" x ¼"	1.75	1.75
1	⅜" x ½"	2.00	2.00
	Pinch dogs, steel		
1 doz.	1" long	.20	2.40
1 doz.	1½" long	.26	3.10
	Planes		
1	core box	12.50	12.50
1	rabbet, 5½"	7.50	7.50
1	router	6.00	6.00
	Shrink rule, steel		
1	12", ¼" shrink	2.75	2.75
1	12", ⅛" shrink	2.75	2.75
	Slips		
1 set	Carving tools, India, set of 4	2.40	2.40
1	Oilstone, India, No. 24, 4½" x 1¾" x ¼" x 1/16", fine	.75	.75
1	Square, combination, with center head and protractor, 12" steel blade	12.00	12.00
	Total		$120.95

[1] For two pupils a class, six classes a day.

[2] These prices are subject to fluctuation.

Unit F: Cold Forming[1]

Note: This list is suggestive. A number of these tools could be used by pupils in other areas. Items, such as bending jigs, forks, and plates, could be made in the metal shop to reduce costs.

Number Required	*Description*	*Cost Each*	*Total Cost*
1	Anvil, 70 to 100-lb. size	$30.00	$30.00
1	Bench (to be made in shop)	———	———
1	Bevel, T, 10″	1.25	1.25
1	Boltcutter, 3/8″ capacity	9.92	9.92
	Calipers		
1	inside, 6″	2.40	2.40
1	outside, 6″	2.40	2.40
	Cans		
1	oil, 1/2 pt.	.30	.30
1	waste, 2 cubic feet	8.25	8.25
	Chisels		
1	cape, 3/8″	.47	.47
1	cape, 5/8″	.69	.69
2	cold, 5/8″	.54	1.08
1	cold, 3/4″	.72	.72
1	diamond point, 3/8″	.84	.84
1	roundnose, 3/8″	.84	.84
	Clamps		
4	C, 4″	1.00	4.00
2	C, 6″	1.50	3.00
	Countersinks		
2	rosehead	.38	.76
2	2-lip	.73	1.46
	Dividers		
1	6″	2.40	2.40
1	8″	2.75	2.75
	Drill		
	electric, 1/2″ capacity	50.00	50.00
	stand for above drill	30.00	30.00
	Drills		
1 set	jobber's, 1/16″ to 1/2″ by 64ths	24.75	24.75
12	1/8″, straight shank	.25	3.00
12	3/16″, straight shank	.45	4.20
6	1/4″, straight shank	.48	2.88
3	5/16″, straight shank	.70	2.10
2	3/8″, straight shank	1.00	2.00
2	7/16″, straight shank	1.35	2.70
1	1/2″, straight shank	1.75	1.75
3 sets	File cards	.93	2.79
	Files		
4	flat, bastard, 6″	.32	1.28
6	flat, bastard, 10″	.50	3.00
2	half-round, double-cut, 6″	.55	1.10
2	half-round, double-cut, 8″	.67	1.34
2	half-round, double-cut, 10″	.82	1.64

[1] This list should be adequate for two pupils. It is assumed that if twelve pupils work in Metal Forming, one-sixth could be assigned to the cold forming unit.

Number Required	*Description*	*Cost Each*	*Total Cost*
	Files (Continued)		
6	mill, smooth, 10″	.40	2.40
4	round, bastard, 8″	.38	1.52
4	square, bastard, 8″	.50	2.00
4	three-square, 8″	.67	2.68
1	Gauge, screw pitch, N. C. and N. F.	2.20	2.20
2 pr.	Goggles	2.00	4.00
	Hacksaw		
½ gr.	blades, hand, 18 teeth, 10″	7.20	7.20
½ gr.	blades, hand, 32 teeth, 10″	7.20	7.20
3	frames, adjustable	2.50	7.50
	Hammers		
1	ball-peen, 13 oz.	1.25	1.25
1	ball-peen, 16 oz.	1.45	1.45
1	ball-peen, 20 oz.	1.60	1.60
1	cross-peen, 32 oz.	2.72	2.72
1	Mallet, wood face	2.02	2.02
1	Nippers, end-cutting, 6″	2.00	2.00
1	Oil stone, Carborundum, 7″ x 2″ x 1″	1.77	1.77
1	Pipe cutter, 1″ capacity	10.20	10.20
	Pliers		
1	combination, 6″	.50	.50
1	combination, 8″	.78	.78
1	side-cutting, 8″	3.34	3.34
	Punches		
3	center, ⅜″	.50	1.50
3	prick, ¼″	.50	1.50
6 sets	Rivets, assorted sizes	1.05	6.30
1	Rule, steel-tempered, 24″	2.50	2.50
	Screwdrivers		
1	6″	.70	.70
1	8″	.84	.84
1	10″	1.03	1.03
2	Scribers	1.05	2.10
1	Snips, tin, 3″ cut	3.98	3.98
1	Soldering iron, 1″ tip, 200-watt, electric	8.40	8.40
1 set	Steel letters, ⅛″, for use on steel	6.38	6.38
	Squares		
1	combination, 12″	4.30	4.30
1	steel, 24″	2.80	2.80
1	Tape, 6′ steel	1.20	1.20
	Taps and Dies		
1 set	¼″ to ¾″ by 16ths	30.00	30.00
1 set	pipe, ⅛″ to 1″	18.00	18.00
1	V-block and clamps	5.50	5.50
1	wheel dresser, No. 0	1.00	1.00
	Vises		
1	drill press, 4″	25.00	25.00
2	machinists', 4″	22.95	45.90
1	pipe, 2″ capacity	8.99	8.99

Number Required	*Description*	*Cost Each*	*Total Cost*
	Wrenches		
1	crescent, 6″	1.26	1.26
1	crescent, 8″	1.49	1.49
1	monkey, 6″	1.50	1.50
1	monkey, 8″	1.75	1.75
1	monkey, 14″	2.46	2.46
1	pipe, 8″	2.00	2.00
1	pipe, 14″	3.50	3.50
	Total		$464.27

CONSUMABLE SUPPLIES LIST

Unit A: Foundry[1]

Amount Required	*Description*	*Total[2] Cost*
300 lbs.	Aluminum alloy	$75.00
10 lbs.	Aluminum flux	3.00
500 lbs.	Sand, molding, Albany 00	25.00
25 lbs.	Sand, parting, non-silica	2.50
	Total	$105.50

Unit B: Forging[1]

Amount Required	*Description*	*Total[2] Cost*
100 lbs.	Clay, fire, for lining forge hearth	$9.00
400 lbs.	Coal, bituminous	2.00
1 doz.	Crayons, soapstone	.28
1 lb.	Flux, welding	.60
	Steel	
	machine, rounds—	
200 ft.	1/4″ dia.	2.73
200 ft.	5/16″ dia.	4.22
100 ft.	3/8″ dia.	6.00
100 ft.	1/2″ dia.	10.58
100 ft.	5/8″ dia.	14.78
100 ft.	3/4″ dia.	22.93
	machine, squares—	
100 ft.	1/4″ x 1/4″	3.00
100 ft.	5/16″ x 5/16″	4.64
100 ft.	3/8″ x 3/8″	6.60
100 ft.	1/2″ x 1/2″	11.64
48 ft.	3/4″ x 3/4″	12.61
	mild, band-iron—	
100 ft.	1/4″ x 1″	13.75
100 ft.	1/4″ x 1 1/4″	17.50
100 ft.	1/4″ x 1 1/2″	20.72
100 ft.	3/8″ x 1 1/4″	27.50
100 ft.	3/8″ x 1 1/2″	29.88
	tool, octagon	
100 ft.	1/2″	35.00
100 ft.	5/8″	50.00
100 ft.	3/4″	71.00
	Total	$376.96

[1] For two pupils a class, six classes a day.

[2] These prices are subject to fluctuation.

Unit C: Welding[1]

Amount Required	*Description*	*Total[2] Cost*
110 cu. ft.	Acetylene	$4.65
	Arc Welding Electrodes, steel, coated	
25 lbs.	3/32" dia., A. W. S. E-6012	3.25
50 lbs.	1/8" dia., A. W. S. E-6012	6.50
50 lbs.	5/32" dia., A. W. S. E-6012	6.50
50 lbs.	1/8" dia., A. W. S. E-6010	6.50
50 lbs.	5/32" dia., A. W. S. E-6010	6.50
	Flux	
1 lb.	Brazing	.60
1 lb.	Cast Iron	.60
	Oxyacetylene welding wires, aluminum, coated	
5 lbs.	3/32" dia.	5.45
5 lbs.	1/8" dia.	4.45
	Bronze	
10 lbs.	1/16" dia.	9.08
10 lbs.	3/32" dia.	8.08
10 lbs.	1/8" dia.	7.58
	Cast Iron	
10 lbs.	1/8" dia.	3.90
10 lbs.	3/16" dia.	2.80
	Mild Steel	
50 lbs.	1/16" dia.	11.50
50 lbs.	3/32" dia.	10.00
50 lbs.	1/8" dia.	9.50
110 cu. ft.	Oxygen	2.34
	Steel	
8 sheets	Black annealed, 24" x 96", 18 gauge	9.98
	Mild Steel, angles	
100 ft.	1/8" x 1" x 1"	8.18
100 ft.	1/8" x 1 1/2" x 1 1/2"	12.40
	Mild Steel, Band Iron	
100 ft.	1/16" x 1/2"	2.50
100 ft.	1/8" x 1/2"	4.35
100 ft.	1/8" x 3/4"	5.93
100 ft.	1/8" x 1"	7.65
100 ft.	1/8" x 1 1/2"	11.34
100 ft.	3/16" x 5/8"	7.60
100 ft.	1/4" x 3/4"	10.92
100 ft.	1/4" x 1"	13.75
100 ft.	1/4" x 1 1/4"	16.75
100 ft.	1/4" x 1 1/2"	20.72
	Mild Steel, Round	
100 ft.	3/16" dia.	1.55
100 ft.	3/8" dia.	4.71
100 ft.	1/2" dia.	8.00
	Mild Steel, Square	
100 ft.	3/8" x 3/8"	5.34
100 ft.	3/4" x 3/4"	19.49

[1] For two pupils a class, six classes a day.

[2] These prices are subject to fluctuation.

Amount Required	*Description*	*Total[2] Cost*
	Pipe	
105 ft.	½" dia.	13.65
105 ft.	¾" dia.	17.85
105 ft.	1" dia.	26.25
63 ft.	1¼" dia.	21.42
63 ft.	1½" dia.	25.83
	Scrap Cast Iron	
100 lbs.	¼" thick in various widths and lengths	5.00
	Scrap Steel Plates	
200 lbs.	various widths and lengths in the following thicknesses: 3/32", ⅛", 3/16", ¼", 5/16", ⅜"	10.00
	Total	$400.94

Unit D: Heat Treatment[1]

Amount Required	*Description*	*Total[2] Cost*
10 lbs.	Carburizing material, charcoal base	$10.00
10 lbs.	Clay, fire	1.00
50 sheets	Cloth, emery, 00 grade	5.62
5 lbs.	Kasenit, surface-hardening compound	9.00
10 lbs.	Lime or insulating mica or clean cast-iron chips	.80
5 gals.	Oil, quenching, mineral	2.90
	Steel	
5 lbs.	Drill rod, polished carbon, .042 lbs. per foot, ⅛" dia.	3.32
10 lbs.	Drill rod, polished carbon, .167 lbs. per foot, ¼" dia.	3.32
50 lbs.	Hot-rolled, SAE 1020, .850 lbs. per foot, ½" square	5.13
50 lbs.	Tool, Carpenter Brand, #11 special, water-hard matched, .850 lbs. per foot, ½" square	21.25
50 lbs.	Tool, carbon, SAE 1090, 1.586 lbs. per foot, ¾" octagon	14.39
	Total	$76.73

Unit E: Patternmaking[1]

Note: Only special patternmaking supplies are listed here. It is assumed that supplies for a unit in bench and machine woodworking are available.

Amount Required	*Description*	*Total[2] Cost*
2 lbs	Beeswax	$0.50
	Brushes	
1	glue, 1" flat	1.44
1	glue, ½" round	.66
1	marking, #2 round	.69
1	marking, #4 round	.79
1	marking, #6 round	.94
1	shellac, 1" x 1½"—set in rubber	2.80
	Dowels, birch	
1 doz.	¼" dia. x 36"	.40
1 doz.	5/16" dia. x 36"	.40
1 doz.	⅜" dia. x 36"	.65

[1] For two pupils a class, six classes a day.

[2] These prices are subject to fluctuation.

Number Required	*Description*	*Cost Each*	*Total*[2] *Cost*
	Dowel centers		
1	¼″ dia.		$.10
1	5/16″ dia.		.10
1	⅜″ dia.		.10
	Dowel pins, brass		
100	⅜″ x 1½″		1.00
100	⅜″ x 2″		1.20
100	⅜″ x 2½″		1.60
2	Dusters, bench, 8″		1.74
	Fillets, leather		
24 ft.	⅛″ radius		.96
24 ft.	¼″ radius		1.92
	Pattern woods		
40 bd. ft.	white pine, clear, 1″ S2S to ¾″		17.60
40 bd. ft.	mahogany, clear, 1″ S2S to ¾″, 2′ to 5′ lengths		17.20
	Pattern lacquers		
1 qt.	white, black, red, yellow, and green		6.25
100 lbs.	Plaster of Paris		2.00
1 gal.	Shellac, orange, 4 lb. cut		3.95
	Total		$64.99

Unit F: Cold Forming[1]

Note: Some of these supplies may be duplicated in other areas.

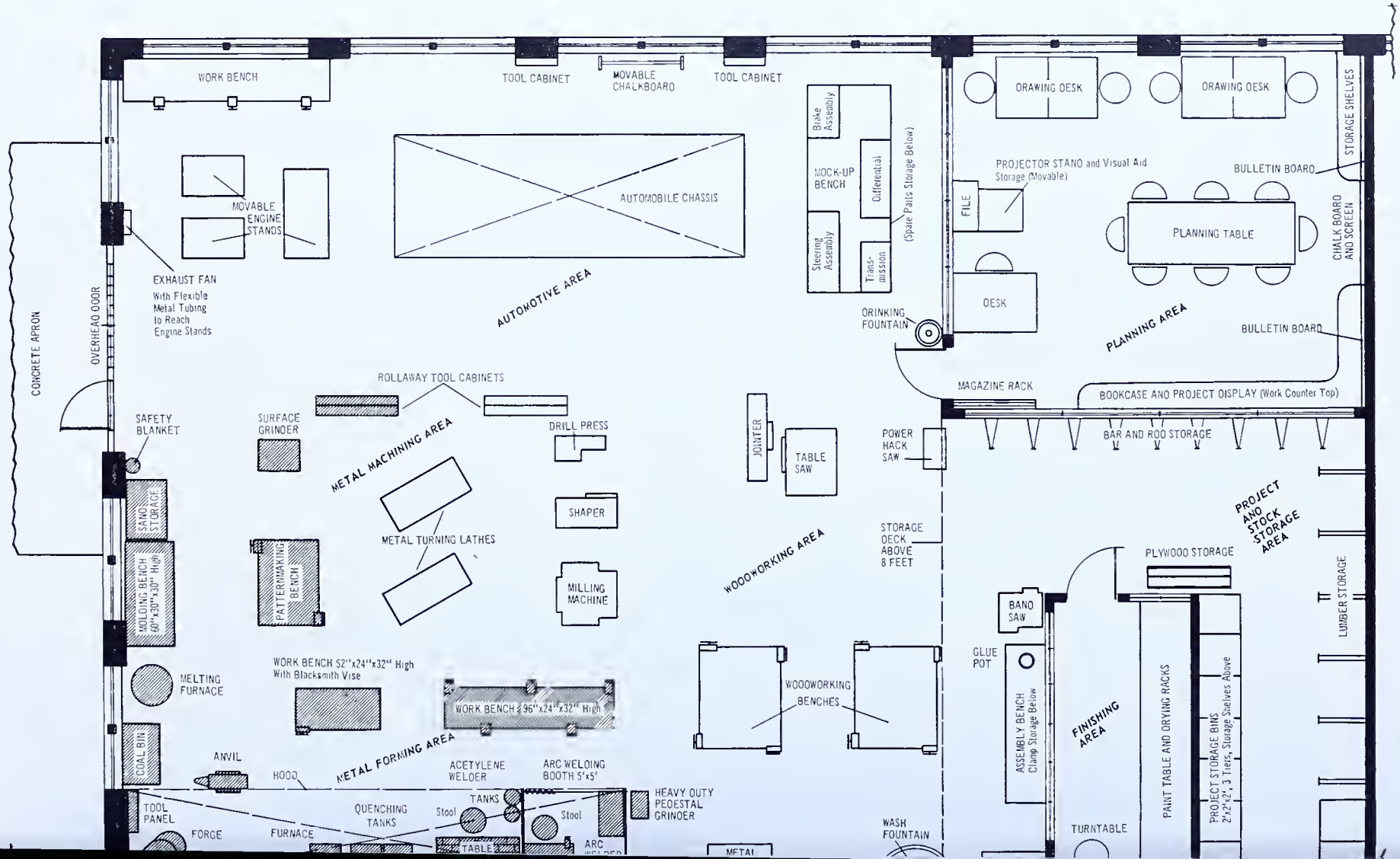
Amount Required	*Description*	*Cost*[2]
	Bolts, stove, round head	
100	3/16″ diameter x ¾″	$ .70
100	3/16″ diameter x 1″	.75
100	3/16″ diameter x 2″	1.09
100	3/16″ diameter x 3″	1.54
100	¼″ diameter x ¾″	1.04
100	¼″ diameter x 1″	1.09
	Enamel	
2 qts.	black, flat	2.50
2 qts.	black, gloss	2.80
	Iron	
	angle, hot-rolled, in 20′ lengths	
100 ft.	⅛″ x 1″ x 1″	8.18
100 ft.	⅛″ x ¾″ x ¾″	6.14
100 ft.	⅛″ x ½″ x ½″	4.04
	band, hot-rolled, in 20′ lengths	
100 ft.	1/16″ x ½″	2.50
100 ft.	1/16″ x ¾″	3.25
100 ft.	⅛″ x ⅜″	2.75
100 ft.	⅛″ x ½″	4.34
100 ft.	⅛″ x ¾″	6.85
100 ft.	⅛″ x 1″	9.95
	black annealed sheets, 24″ x 96″	
5 sheets	26-gauge	10.75
4 sheets	24-gauge	10.52
3 sheets	22-gauge	8.52
3 sheets	20-gauge	9.60
2 sheets	18-gauge	9.14

[1] For two pupils a class, six classes a day.
[2] These prices are subject to fluctuation.

Number Required	Description	Cost Each	Total[2] Cost
	Iron (continued)		
	round, hot-rolled, in 20′ bars		
100 ft.	3/16″		$1.55
100 ft.	1/4″		2.37
100 ft.	3/8″		4.71
100 ft.	1/2″		8.00
	square, hot-rolled, in 20′ bars		
100 ft.	1/4″ x 1/4″		2.65
100 ft.	3/8″ x 3/8″		5.34
100 ft.	1/2″ x 1/2″		9.07
2 qts.	Lacquer, clear, for metal		2.80
1 gal.	Linseed oil, boiled		3.25
	Nuts, wing		
100	1/4″		2.30
100	3/16″		2.88
	Rivets, soft iron, round head		
2 lbs.	1/8″ diameter x 3/8″		1.06
2 lbs.	1/8″ diameter x 1/4″		1.24
2 lbs.	1/8″ diameter x 5/8″		.96
2 lbs.	3/16″ diameter x 1/4″		.72
2 lbs.	3/16″ diameter x 3/8″		.72
2 lbs.	3/16″ diameter x 5/8″		.64
	Rivets, soft iron, flat head		
2 lbs.	1/8″ diameter x 3/8″		1.06
2 lbs.	1/8″ diameter x 1/4″		1.24
2 lbs.	1/8″ diameter x 5/8″		.96
2 lbs.	3/16″ diameter x 1/4″		.72
2 lbs.	3/16″ diameter x 3/8″		.72
2 lbs.	3/16″ diameter x 5/8″		.64
	Washers, wrought steel, for bolt sizes:		
2 lbs.	3/16″		.62
2 lbs.	1/4″		.56
	Wire, tinned, annealed		
5 lbs.	No. 14		1.79
5 lbs.	No. 16		2.04
	Total		$168.65

[1] For two pupils a class, six classes a day.

[2] These prices are subject to fluctuation.


WORK BENCH
TOOL CABINET
MOVABLE CHALKBOARD
TOOL CABINET
ORAWING OESK
ORAWING OESK
STORAGE SHELVES
Brake Assembly
MOCK-UP BENCH
Differential
Steering Assembly
Trans-mission
(Spare Parts Storage Below)
PROJECTOR STAND and Visual Aid Storage (Movable)
BULLETIN BOARD
FILE
PLANNING TABLE
CHALK BOARD AND SCREEN
MOVABLE ENGINE STANDS
AUTOMOBILE CHASSIS
EXHAUST FAN
With Flexible Metal Tubing to Reach Engine Stands
AUTOMOTIVE AREA
OESK
ORINKING FOUNTAIN
PLANNING AREA
BULLETIN BOARD
CONCRETE APRON
OVERHEAD DOOR
ROLLAWAY TOOL CABINETS
MAGAZINE RACK
BOOKCASE AND PROJECT DISPLAY (Work Counter Top)
SAFETY BLANKET
SURFACE GRINDER
METAL MACHINING AREA
DRILL PRESS
JOINTER
TABLE SAW
POWER HACK SAW
BAR AND ROD STORAGE
SAND STORAGE
MOLDING BENCH 60"x30"x30" High
PATTERNMAKING BENCH
METAL TURNING LATHES
SHAPER
MILLING MACHINE
WOODWORKING AREA
STORAGE DECK ABOVE 8 FEET
PROJECT AND STOCK STORAGE AREA
PLYWOOD STORAGE
LUMBER STORAGE
BAND SAW
GLUE POT
ASSEMBLY BENCH Clamp Storage Below
FINISHING AREA
PAINT TABLE AND DRYING RACKS
PROJECT STORAGE BINS 2'x2'x2', 3 Tiers, Storage Shelves Above
MELTING FURNACE
WORK BENCH 52"x24"x32" High With Blacksmith Vise
WORK BENCH 96"x24"x32" High
WOODWORKING BENCHES
COAL BIN
ANVIL
HOOD
METAL FORMING AREA
ACETYLENE WELDER
ARC WELDING BOOTH 5'x5'
HEAVY DUTY PEDESTAL GRINDER
TOOL PANEL
QUENCHING TANKS
TANKS
Stool
Stool
FORGE
FURNACE
TABLE
ARC WELDER
METAL
WASH FOUNTAIN
TURNTABLE

7 Suggested Shop Layout

Industrial Arts shop facilities are an essential part of the architectural plans for secondary school buildings. Since these plans vary, it is difficult to prepare standard Industrial Arts shop layouts.

On page 62 a suggested layout is shown for a comprehensive general shop with the following Industrial Arts areas:

1. Automotive
2. Metal Forming
3. Metal Machining
4. Planning
5. Woodworking

Other Industrial Arts areas may be substituted to meet the needs of the particular local school situation. Metal Machining is included in this suggested layout because some projects made in the foundry unit will need to be machined, and some projects made in the Metal Machining Area will need to be heat-treated in the heat-treatment unit. Woodworking is included because of its close relationship to the patternmaking unit in the Metal Forming area.

All areas may use the same planning, finishing, and storage facilities, and all areas are used by the pupils in Metal Forming. This overlapping of areas is necessary because of the varied nature of activities in this course.

The total shop area is approximately 2100 square feet. Other supplementary bulletins in this Industrial Arts series contain information concerning equipment for areas other than Metal Forming.

NOTES